POWER

A McGRAW-HILL PUBLICATION—ESTABLISHED 1884

FRED R. LOW, *Editor*

Volume 70 NEW YORK, OCTOBER 22, 1929 *Number 17*

The Prospects of the Power Plant Engineer

WE HAVE occasional despondent letters from men who are or have been operating power plants, deploring their meager pay and narrowing opportunities.

Many of the plants formerly operated by such men are buying their power from the public utilities.

There are a lot of operations that used to be domestic, local and individual that are now conducted collectively by institutions equipped to do them on a mass-production basis.

Mother doesn't bake the family loaf any more. Even the local baker is succumbing to the bread, cake and pie factory.

The making of light and power has become a major industry, and many companies, some of them of considerable size, have concluded that they had better buy their electricity from those who make a business of generating it.

Again, the trend toward consolidation, aggregation, large-scale operation has materially reduced the number of manufacturing establishments. Capacity is maintained by fewer large installations instead of by more numerous small factories or shops.

All of which does reduce the demand for and the opportunity of the man who performs the manual and mechanical operations of keeping a small plant running.

But the enormous increase in the use of power, its production in large units by the newer methods and the multiplicity of services demanded from the modern power plant have greatly enhanced the opportunities for men who are competent to run the plant instead of just the engine.

The aggregation of a number of small establishments into one big combination produces a load that warrants the maintenance of a privately owned power plant to run it.

And even in smaller plants the multiplicity of services and their interrelation often make it possible for the engineer who knows modern methods and apparatus to obtain the combined result more cheaply by generating than by purchasing power.

I have no statistics on the subject, but believe that it is safe to assume that much more money is being paid in the aggregate to engineers in responsible charge of power plants than ever before.

F. R. Low

POWER *Stands for . . .*

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application

Power Industry's Jubilee

TERMINATING a five months' spectacle, the greatest in the history of electric illumination, "Light's Golden Jubilee" celebration reached a grand climax on Oct. 21 at the meeting of the Edison Pioneers in Dearborn, described on pages 660 and 661 of this issue of *Power*. Held in honor of Thomas Alva Edison, the celebration was much more than a recognition of his part in the invention of the incandescent lamp. It was a tribute to the creation of a whole system of lighting which can well be called the real beginning of the electrical industry.

Many authorities do not even give Edison credit for the invention of the lamp itself. The Encyclopedia Britannica lists Sir Joseph Swan as the inventor of the first practical lamp. Records show that as early as 1820 De la Rue actually made an incandescent lamp with a coil of platinum wire sealed in a piece of glass tubing. In 1840 Sir William Grove gave a lecture before the Royal Society during which he demonstrated his battery by lighting the auditorium with electric lights. The first patent on an incandescent lamp was granted by the British government to Frederick De Moleyns in 1841. J. W. Starr, an American living in Cincinnati, devised a lamp in 1845, on which he obtained a patent in England. The Electric-Technic Society, of Hanover, Germany, recently unveiled a tablet to Heinrich Goebel as having invented the incandescent lamp. And there are many other claims from other countries.

Thomas A. Edison, however, was the first to devise a commercially practical electric lighting system, of which the lamp was only one factor. He conceived a satisfactory method of distributing electric current to houses, stores and factories. He devised a meter to measure the energy used. He designed and built efficient generators and means for regulating them. Without all of these, his successful incandescent lamp would have been little more than an interesting experiment, like those that went before. It would not have provided the impetus to the production of electric power which has brought power generation to the state of perfection and importance it now enjoys.

Another Investigation of Education

DESPITE all efforts of cracker-barrel philosophers, industrialists, individual pedagogues, even great commissions of experts, the subject of education will undoubtedly continue to defy ultimate analysis. Admitting that its aim is to train the individual to do, and be, that which is most worth while, the honest investigator is confronted at the very start with the unanswerable question, "What is most worth while?" All investigations of education necessarily start off with certain unproved, and unprovable, assumptions as to the object to be obtained.

It is therefore clear that no final "solution" of educational problems can be attained by a commission, however distinguished, appointed to make "an appraisal of contemporary public education, as it affects the adjustment of youth to vocational life in the United States," as proposed last week by the National Industrial Conference Board. Nevertheless, the personnel of the Advisory Committee, embracing leading men in industry and education, promises a study of unusual breadth and practicality.

From the point of view of the engineer, it is significant that the list includes the name of W. E. Wickenden, recently elected president of the Case School of Applied Science and for several years past director of the investigation conducted under the auspices of the Society for the Promotion of Engineering Education. President Wickenden's wonderful grasp of the whole field of engineering education should go far to insure conclusions of value in those phases of the work that particularly concern engineers and the engineering schools. Certainly the results obtained in the S.P.E.E. study should have an important place in this larger appraisal.

Boiler Compounds and Patent Medicines

UNDER the pure-food laws it is compulsory that patent medicines be labeled to indicate the drugs that enter into their composition. This represents no attempt to pass upon the merits of the particular combination; it merely serves as a protection to the consumer by informing him as to the contents. The effect has not been the eradication of patent medicines, but has resulted in the discouragement of many cure-all nostrums that formerly flourished on the strength of their claims alone.

Applied to the mechanical field, is not the case somewhat analogous to boiler compounds? Just as the pure-food laws afford protection to the human machine, is it not reasonable to protect the boiler user by letting him know exactly what he is putting into his feed water, in order that he may judge whether it may be harmful to the boiler metal?

Boiler compounds have been, and are, widely used. On the one hand, they have been enthusiastically indorsed by as many operators as have condemned them, on the

other. Making allowance for the exaggeration of some indorsements and the prejudice of some condemnations, it is reasonable that certain compounds are effective in meeting certain conditions. Others may have little effect in many cases, but are harmless; while a few may be distinctly harmful under certain conditions. That no compound is a panacea for all boiler ills is obvious. This of course does not apply to cases where the prescription is made up to suit the particular water conditions.

With present operating practice subjecting the modern boiler to more severe service, the need for intelligent treatment of the feed water becomes of vital importance. It has been suggested that boiler compounds be labeled as to their contents, so that the operator may be governed accordingly. This can be brought about only by general insistence on the part of the user.

Favorable Heat Balance With a Diesel-Steam Plant

THE combination of a steam and a Diesel engine in the power plant of R. H. Macy & Company, one of the world's largest department stores, and in the New Yorker, a new hotel in New York City, has focused the attention of engineers upon the highly favorable heat balance obtainable through such a combination.

During the winter months most factories find that the exhaust from the steam engines just about meets the heating requirements. For six months power is generated at an exceptionally low cost. With the coming of spring, this Utopia of the power engineer proves chimerical: The money saved during the winter may be entirely consumed by the high operating costs through the warm months. Where condensing water is available, of course, a fair degree of economy is obtainable throughout the year. But the addition of a highly efficient oil engine to the steam plant brings back some of the economy obtained during the heating season. It can produce ten kilowatt-hours or more from a gallon of oil, at a fuel cost of less than one-half of a cent per kilowatt-hour. Since it is almost always necessary to maintain an all-year engine room force, there is no added labor charge. With proper apparatus, the heat absorbed by the jacket water and about one-half the heat in the exhaust gases can be recovered in the form of hot water, always in demand in a factory, office building or hotel. This means that the over-all efficiency of the Diesel is equal to that of the usual boiler, say seventy per cent.

If, as in case of a hotel or store, low-pressure steam is needed at all times, the most economical heat balance is obtained by loading the steam engines to a point where the atmospheric relief valve on the system starts to open, carrying the remainder of the load on the Diesel.

The only objection that might be raised to the combined plant is that of initial investment. But the cost of Diesels when added to an existing steam plant does not mean an entire duplication of the investment. If the load conditions are favorable the combined plant will justify its cost.

Research on Wire Rope

WIRE ROPE has come to be an important material in practically all hoisting operations. Notwithstanding its importance and the large quantities used, comparatively little research has been done to determine the influence of those factors that affect rope life in service. Some work of interest has been done by different groups both in this country and abroad, but none has attacked all the ramifications of the problem. It is to this task that the proposed co-operative research committee, now being organized under the auspices of Engineering Foundation and the American Society of Mechanical Engineers, should devote attention.

The task the committee has before it is a difficult one, but the possibilities of economic gain are large. One has only to consider that one set of elevator ropes may give sixty thousand car-miles—and another less than nine thousand—to realize the economic importance of the problem. This wide variation in the life of wire rope occurs in applications other than elevator service. Efforts to explain this inconsistency in rope life have given rise to about as many different opinions as there are variations of conditions. Most of these opinions are based on some particular operating condition rather than on fundamental knowledge. The user blames the rope, and the rope manufacturer passes the blame to the user and to the conditions under which the rope is used. In most cases neither one can prove his case; nor will he be able to do so until the factors that affect rope life have been evaluated by exhaustive search.

A great deal of discussion has been centered on reserve strength of used wire rope. Research will probably show this factor to be of only minor consequence. One of the first things that the user of rope should know is that he is getting a uniform product—uniform in material and in fabrication. The action of rope in service indicates that there is a wide variation in wire rope of the same construction and supposedly made of the same material.

Until it can be determined what the quality of the finished rope is before it goes into service, it will be difficult to determine the reserve life of a used rope, or the effect of service conditions. It is therefore just as important that a method be devised to give the quality of the fabricated rope as it is to determine the influence of operating conditions on the rope after it goes into service.

"Foresight is cheaper than hindsight," as many an industrial executive has found to his cost. Not all eventualities can be foreseen, of course, but much money and trouble could be saved in industry if engineers and executives would make a more careful analysis of conditions and possibilities before initiating important developments. Even with the best of foresight later experience will make advisable some shifts in the original plans, often at substantial cost. Here excessive pride—failure to admit an error—may prove a pitfall just as sheer mental laziness may be a pitfall at the start.

Five Paper Mills POOL POWER

Loads and Sources

By pooling the loads and generating equipment of its five mills on the Housatonic River near Lee, Mass., by making effective use of synchronous condensers and by shifting the start of the "power-contract" year the Smith Paper Company has made substantial savings in the energy and maximum demand charges for purchased current

BY HENRY W. TAYLOR
Consulting Engineer, New York City

A RECENT review of power data supplied by the Smith Paper Company, of Lee, Mass., brought out several situations that could be adjusted to reduce power costs. This study was made at the time of the maturity of an existing electric contract and looked toward the revision of this contract to better suit conditions that had developed during its life, and also toward the adaptation of the use of power and equipment to reduce excessive costs where possible.

The Smith Paper Company operates five paper mills distributed along the shore of the Housatonic River near Lee, Mass. The original layout of the mills doubtless conformed to available water power sites along the river, and all of the mills were operated in part by direct water-wheel drive to the main shafting. However, the power demands of these mills outgrew the resources of the river some twenty years ago, and the Pittsfield Electric Company installed a transmission line south from Pittsfield to take care of the increased requirements.

Due to lack of synchronism in the operation of the five mills, it was impossible to get full use of such water power as was available, so that a considerable amount of water was wasted when one mill was shut down or was operating under a partial load, and more was wasted at high flows of the river, when available wheel capacity was limited.

Consequently, in 1923, the writer combined the available power at two mill sites to form one head, and this power was utilized by a modern hydro-electric development. By conversion of this water power into electrical energy it was also possible, through the medium of the Pittsfield electric transmission line, to distribute the power from the new hydro-electric station to any one of the five mills where it could be utilized.

In each of the mills is a combination of direct-drive hydraulic power, motor-driven machinery, and power

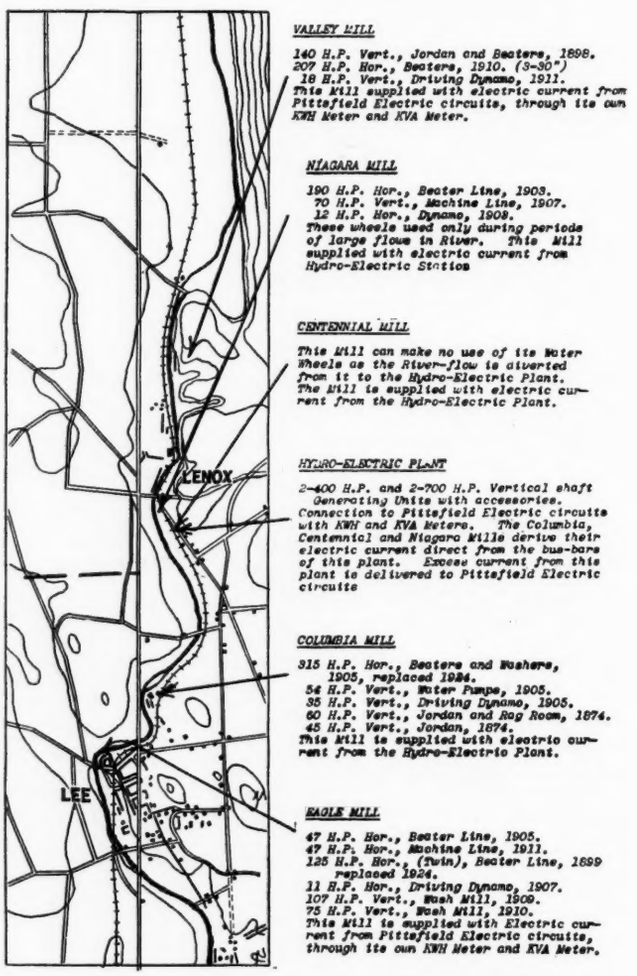

LENOX
LEE
VALLEY MILL
140 H.P. Vert., Jordan and Beaters, 1898.
207 H.P. Hor., Beaters, 1910. (3-30")
18 H.P. Vert., Driving Dynamo, 1911.
This Mill supplied with electric current from Pittsfield Electric circuits, through its own KWH Meter and KVA Meter.
NIAGARA MILL
190 H.P. Hor., Beater Line, 1903.
70 H.P. Vert., Machine Line, 1907.
12 H.P. Hor., Dynamo, 1908.
These wheels used only during periods of large flows in River. This Mill supplied with electric current from Hydro-Electric Station
CENTENNIAL MILL
This Mill can make no use of its Water Wheels as the River-flow is diverted from it to the Hydro-Electric Plant. The Mill is supplied with electric current from the Hydro-Electric Plant.
HYDRO-ELECTRIC PLANT
2-400 H.P. and 2-700 H.P. Vertical shaft Generating Units with accessories. Connection to Pittsfield Electric circuits with KWH and KVA Meters. The Columbia, Centennial and Niagara Mills derive their electric current direct from the bus-bars of this plant. Excess current from this plant is delivered to Pittsfield Electric circuits
COLUMBIA MILL
315 H.P. Hor., Beaters and Washers, 1905, replaced 1924.
54 H.P. Vert., Water Pumps, 1905.
35 H.P. Vert., Driving Dynamo, 1905.
60 H.P. Vert., Jordan and Rag Room, 1874.
45 H.P. Vert., Jordan, 1874.
This Mill is supplied with electric current from the Hydro-Electric Plant.
EAGLE MILL
47 H.P. Hor., Beater Line, 1905.
47 H.P. Hor., Machine Line, 1911.
125 H.P. Hor., (Twin), Beater Line, 1899 replaced 1924.
11 H.P. Hor., Driving Dynamo, 1907.
107 H.P. Vert., Wash Mill, 1908.
75 H.P. Vert., Wash Mill, 1910.
This Mill is supplied with Electric current from Pittsfield Electric circuits, through its own KWH Meter and KVA Meter.

Fig. 1—Map showing locations of mills and hydro-electric plant of the Smith Paper Company

shafts driven both by water power and by electric motors as a make-up. Each mill was served by its own kilowatt-hour and kilovolt-ampere meters. After the completion of the hydro-electric plant an arrangement was made with the Pittsfield Electric Company whereby the excess power which was not delivered directly to three of the mills was carried to the other two mills and credit allowed for this current against the Pittsfield Electric Company's kilowatt-hour bill less a percentage for losses in transmission.

There was, however, no kilovolt-ampere credit for this power produced by the owner. Moreover, the kilovolt-ampere totals from the various mills were often not in synchronism and could at no time be readily totaled to find the peak. These peak kilovolt-ampere demands

could, under these conditions, hardly be avoided, since they could not readily be determined and were not known until after the damage had been done. Due to the use of induction motors, the power factor at the mills ranged from 50 to 60 per cent until capacitors were installed, the effect of which was immediately felt.

Fig. 1 shows the location of the various mills and gives a description of the water power situation at each of them. It also shows the location and capacity of the hydro-electric station.

The electric contract of 1924 matured in January, 1929, and it was felt that a study of the five-year period would divulge ways and means of improving existing power costs. A large amount of information relating to the kilowatt and kilovolt - ampere history of the five mills from 1924 to 1928, inclusive, was tabulated and plotted in the form of total electric power used, total electric power purchased, and that manufactured by the owner, together with the peak kilovolt-ampere demands for which the company had been billed. Fig. 2 shows the curves developed for 1924, a year which included the more glaring faults and was subject to the maximum of correction.

Study of the various years, compositely arranged, showed that the period of contract was not best suited to the case, as there proved to be a decided drop in power purchased about the first of April, due both to a drop in output and also an increase in the amount of power produced by the owner during the spring floods.

The former contract had set Jan. 1 as the beginning and end of the kilovolt - ampere demand year, and as this demand was built up its maximum peak was carried through for the remainder of the contract year. It was found that a maximum for the year was often established in January, and this peak extended through the mid-year drop in power purchased, which began about April 1 and continued until September or October.

The second factor in the contract (which was subject to revision) was the base rate paid for energy, together with a coal clause which, under the existing operation of the power company, was of only nominal importance. The third element which seemed to require revision, both for accuracy and for the benefit of the owners' observers, was the method of measuring the kilovolt-ampere demand. It happened that the power company had available a second circuit, which could be used for local distribution to the five mills, and an arrangement was made by which a kilovolt-ampere high - tension meter located at the hydro-electric station measured at one point all the kilovolt-amperes delivered, which were then distributed through the second circuit to the individual mills.

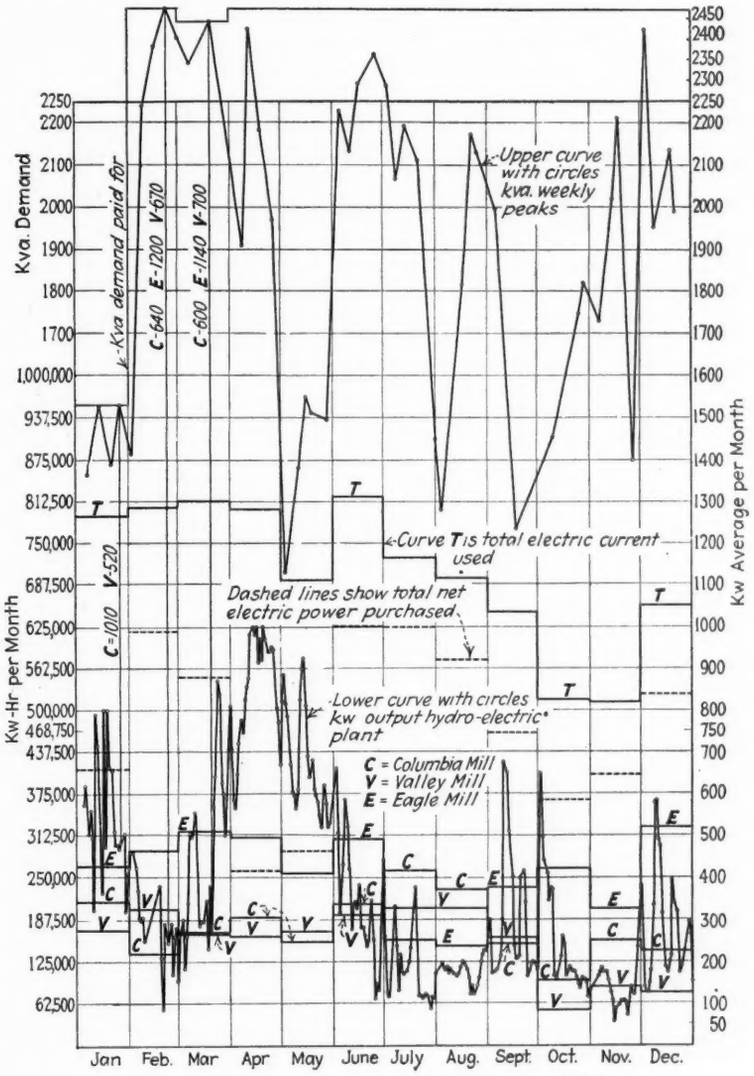

Kva. Demand
Kw-Hr per Month
Kw Average per Month
Kva demand paid for
C-640 E-1200 V-610
C-600 E-1140 V-700
C-1010 V-520
Upper curve with circles kva. weekly peaks
Curve T is total electric current used
Dashed lines show total net electric power purchased
Lower curve with circles kw output hydro-electric plant
C = Columbia Mill
V = Valley Mill
E = Eagle Mill
Jan Feb. Mar Apr May June July Aug. Sept Oct. Nov. Dec.

Fig. 2—Power curves for the year 1924

Load curves for 1924 (Fig. 2) clearly indicate a definite financial loss resulting from the use of the calendar year as the "power-contract" year. The peak of kilovolt-ampere demand occurring early in the calendar year established a maximum that affected charges through succeeding months of lower demand. The peaks shown were greatly reduced by later changes.

This arrangement makes it possible for the operating engineers at the hydro-electric station to observe the peak as it may be built up every half hour, and gives the opportunity for notification of an approaching peak condition, which very often can be forestalled and entirely obviated. I estimate that this centralized measurement and observation of the kilovolt - ampere peak, by neutralizing only one situation in a year's time, saves the owner several thousand dollars. Fig. 2 shows a peak load condition of wide variation, and peaks of short duration. The peak loads are shown as the peak for a given week; those indicated may have been for only 30 min. duration, although, in the general case, they extended over a period of probably one day.

In the hydro-electric station are two 600-kva. vertical-shaft

generators, and two 150-kva. generators. During the low flows of the river the two smaller machines were often able to utilize all the water available. At least one of the large machines remained idle during the summer for several months at a time.

The maximum kilovolt-ampere demand would, naturally, occur at a time when the owner's hydro-electric station was producing a small amount of power, and calling upon the outside circuits for additional energy and demand. However, at this same time, the owner had

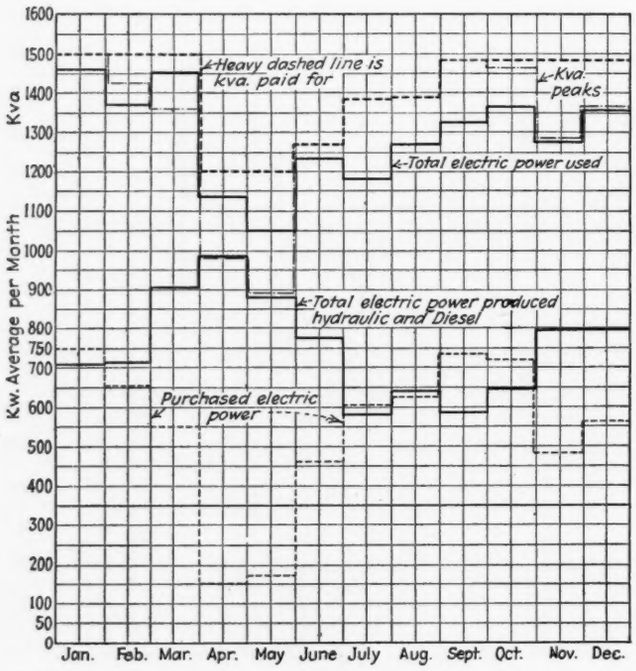


Fig. 3—Composite year representing anticipated conditions

available about 1,000 kva. of rotary condenser capacity which has been reclaimed and put to work. The waterwheels are hung from the generator thrust bearing and, fortunately, the thrust bearing nearest the waterwheel runner is at a point above the wheel case. Since there are no bearings inside the case, no harm results from running the wheel dry. A vacuum breaker pipe was installed in the wheel pit and connected to the draft tube, with valve above the operating floor.

The waterwheels are brought to speed with water power, the generators thrown on the line, the waterwheel gates closed, and the vacuum breaker valve opened, so that the waterwheel runner rotates in air and with little resistance. Thus the generator may be operated satisfactorily as a rotary condenser to raise the power factor and reduce the kilovolt-ampere demand. It was found that this condenser capacity would have produced a saving of $10,000 in the year 1924. It also increased the evaluation of the hydro-electric station at low outputs, and will practically eliminate the present idle machinery in that station, without increased operating expense.

During the process of adjusting the contract to conditions as of 1929 the matter of installing a Diesel generating set for firm power was investigated. In this study a complete Diesel generating set was worked out, to be installed adjacent to the hydro-electric station and to be operated by the same men who had the hydro-electric station in charge. The energy charge, together with the kilovolt-ampere credit resulting from this firm power installation, so closely approximated the revised energy rate of the new contract that the installation was abandoned.

A considerable enlargement of beater capacity in many of the mills has been demanded during the last few months, and the power-factor situation has been further attacked at various points by the installation of synchronous motors. It also seems that the output curve of the industry will gradually grow flatter, inasmuch as orders will be received with more uniformity and without a periodic peak after a dull summer.

Fig. 3 gives a set of prospective curves for the future in case a 300-kw. Diesel generating set were installed. These curves include the benefits to be derived from power-factor adjustment through use of idle generators at the hydro-electric station as rotary condensers. They also take account of the improvement resulting from the installation of capacitors at various mills and that obtainable by a centralized observation of peak loads. The curves include a 20 per cent increase in power consumed for 1930.

Comparison of Fig. 2 and Fig. 3 shows the great benefit resulting from these changes. As stated above, the Diesel generating set will not be installed, but it probably served its purpose by tending to reduce the energy rate in the new contract. The major improvement between the curves for the year of 1924 and that of 1930 is not affected by this omission, as far as comparative characteristics and costs are concerned.

Corrosion of Welds

WHEREVER there is a possibility of corrosion being set up, to minimize the action it is a prime essential that the deposited metal should be as similar in composition as possible to the metal of the original plate. The liability of welds to differential attack is very noticeable when they are macroetched. In addition, inclusions in welds act as nuclei for electrolytic attack.

No matter by what process a weld has been made, if the resulting structure is not uniform and the welded part is likely to be subjected to a corrosive agent, a normalizing treatment, apart from the other improvements it brings, tends to reduce corrosion.

Various classes of welds have been subjected to corrosive influences and their behavior watched. These experiments are still in progress, and it is at present too early for any definite statement to be made on the relative merits.

Of the specimens tested, a good quality carbon-arc weld behaved far the worst, the weld metal being very heavily eaten away. The weld metal, however, behaved considerably better when normalized than when in the as-received condition.

The feature that perhaps was most noticeable was the local attack that took place at the junction of the weld and the plate during the initial stages of attack. With all the welds tested and an acid-corroding medium used, the existence of this local action was evidenced at the surface of the liquid, where fine gas bubbles could be clearly traced reproducing exactly the profile of the weld metal.

Acetylene welds that had been well fused to the original metal were free from local attack.—From Technical Report British Engine Boiler & Electrical Insurance Co. Ltd.

Boiler Metal Cracking

. . . A CASE STUDY

By MAX HECHT and D. S. McKINNEY
Chief Chemist *Chemical Engineer*
Power Stations Department, Duquesne Light Company

Investigation of a mud-drum blowoff pad that cracked after nine years of service indicates that the cracking was due to the combined effects of corrosion and strain in spite of the fact that the "embrittlement" ratio of the boiler water was kept within the limits specified by the A.S.M.E.

LAST YEAR the Duquesne Light Company experienced its first boiler metal failure since it has been operating boiler plants in the Pittsburgh district 15 years. A mud-drum blowoff pad was found cracked, in the fall of 1928, the pad having been in service nine years. The metal had been exposed to water with an adequate sulphate-to-alkalinity ratio.

The cracked blowoff mud-drum pad was one of three originally installed on Boiler Unit 52 in the Brunot Island power station of the Duquesne Light Company. This is a Stirling-type boiler, with 8,220 sq.ft. of heating surface, and is operated at 200 lb. gage pressure. It was fabricated and installed in 1919, and first operated Aug. 1, 1919. The manufacturers did not supply the physical and chemical properties of the specific pad that cracked, but did advise that the materials for the pads were bought under specifications for steel bars, boiler code, 1914 edition, and, further, that the mud-drum connections were forged from billets. The holes were drilled and not punched. All seams were calked on the outside.

Originally, three blowoff valves were installed. These will be designated *X*, *Y* and *Z*, respectively, *Y* being the center pad. Some time during 1920 the valves were removed from the two outside pads *X* and *Z*, and the pipe openings in the pads were plugged with brass screw plugs. Routine blowdowns were made, using the center *Y* valve.

The mud drum, and particularly the blowoff pads, were adequately insulated from furnace temperatures, and the bridge wall of the boiler setting was extended to the center line of the drum.

No leakage of the mud drum pads had been noted in the station logs until Sept. 12, 1928, nine years after installing the boiler. A water leak was then observed around the rivet heads of blowoff pad *Z*, following a hydrostatic test. The initial calking of the external rivet heads on this date did not stop the leak. The external rivet heads cracked when additional calking was tried. No leaks were noted around the pads *X* and *Y* of this boiler.

The Brunot Island station has been operated since 1912 as a surface-condensing plant. The condensate returns since 1918 averaged 90 to 95 per cent of the boiler feed-water requirements. In 1914 a cold-intermittent water softener was installed, and since 1918 the treated make-up averaged 5 to 10 per cent of the feed.

Ohio River water is treated using iron sulphate as the coagulant and lime and soda ash for the softening chemicals. This is a high-sulphate water. The condensate returns and make-up are mixed in open heaters, the oxygen content of the mixed feed water averaging 0.5 cc. per liter.

Available analyses of the feed water are shown in Table I, and of concentrated boiler water in Table II. The embrittlement ratios shown in Table III were found in concentration tests run on a unit similar to the one in which the pad failure was found.

The authors have observed, and show in Table III, that an adequate embrittlement ratio is established in the boiler water after a few days of concentration. (The requirements of the recommendations of the A.S.M.E. code are interpreted by the authors to mean maintenance of the recommended ratio in the concentrated water, although the published recommendation does not specifically state it in this manner. The failure of the introduced feed water to possess the prescribed ratio does not imply an inadequacy of the ratio in the boiler water.)

A thin deposit of lime compounds has been and is found covering the internal surfaces of the drums and boiler tubes. The presence of the coating provides

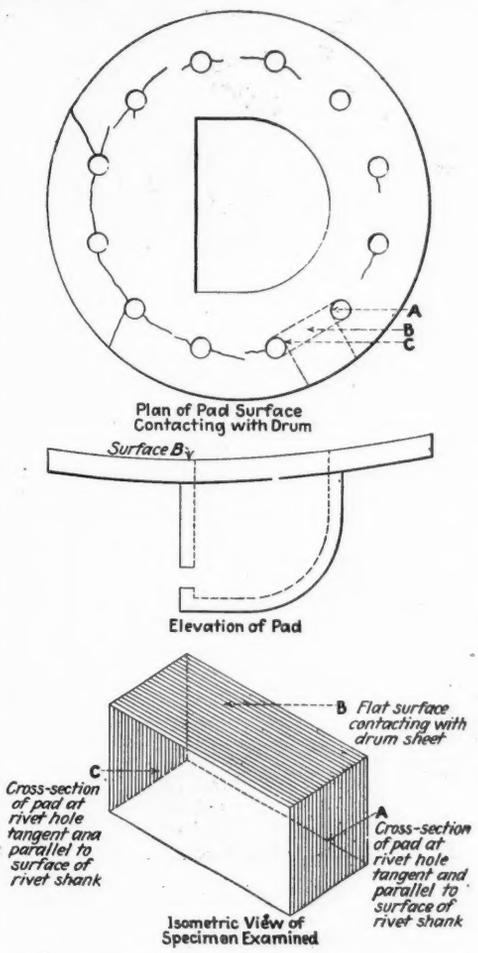

A
B
C
Plan of Pad Surface Contacting with Drum
Surface B
Elevation of Pad
B Flat surface contacting with drum sheet
C
Cross-section of pad at rivet hole tangent and parallel to surface of rivet shank
A
Cross-section of pad at rivet hole tangent and parallel to surface of rivet shank
Isometric View of Specimen Examined

Fig. 1—Sketches of pad that failed and specimen cut out for study

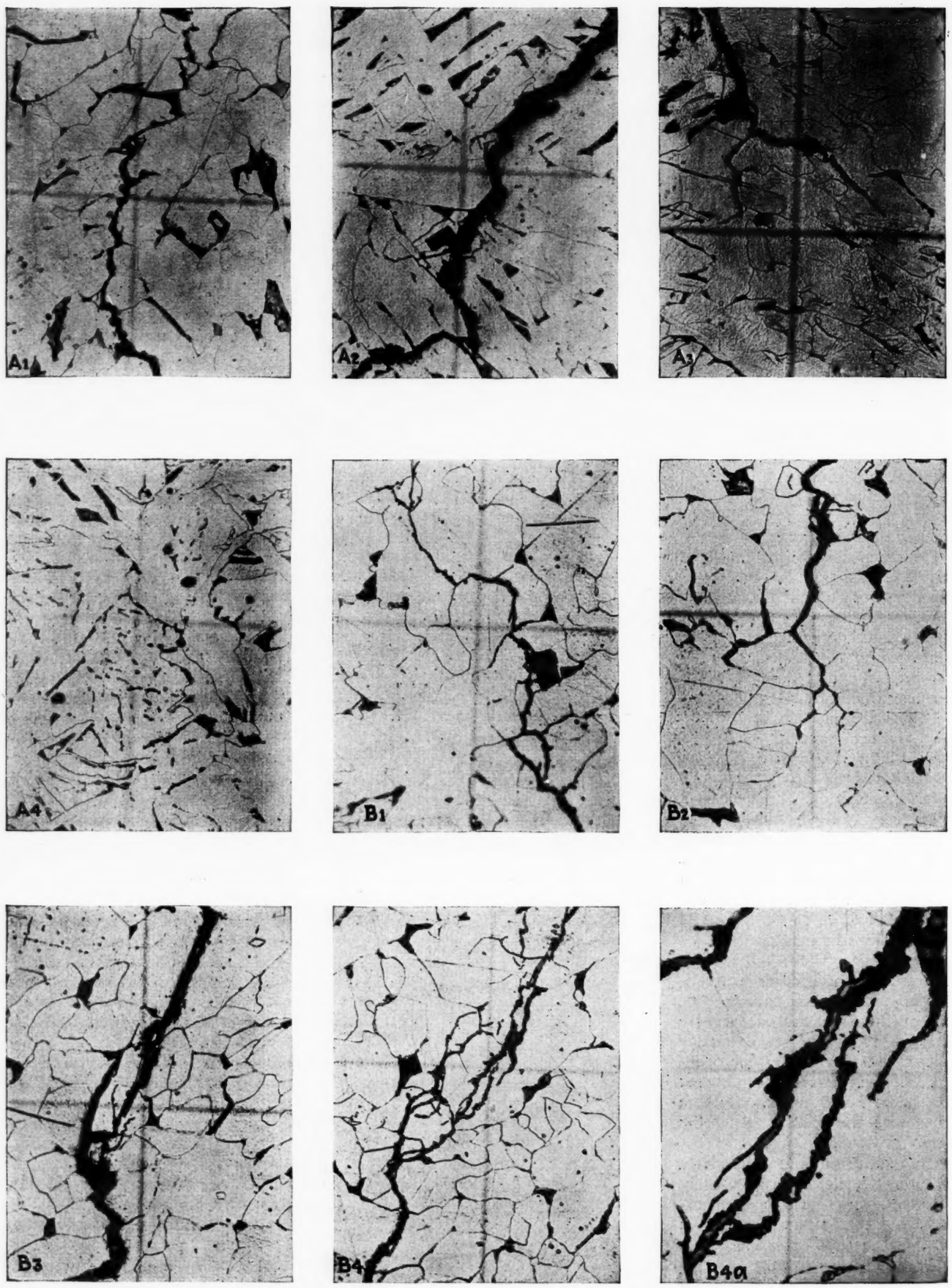


Fig. 3—Photomicrographs of portions of surfaces shown in Fig. 2. All are reproduced 180 diameters (photographs 250 diameters) except B4a, which is 750 diameters (photograph 1,050 diameters). The photographs are located as follows on Fig. 2:

Photos on A		Photos on B	
A1 at 12e	A3 at 8h	B1 at 13h	B3 at 22c
A2 at 4g	A4 at 5j	B2 at 20i	B4 at 16b

protection against any inherent corrosive properties which the water may possess.

At routine cleaning periods the recessed sections of the plugged blowoff pads are cleaned by flushing. No unusual accumulation of deposit has been found in them.

When the pad *Z* was removed from the mud drum, it was noted that the curvature of the pad did not conform to that of the mud drum, leaving spaces between the pad and drum. The cracks were found on the drum

TABLE I—BOILER FEED-WATER ANALYSES
(All values in parts per million.)

	Jan. 6, 1922	March 9, 1922	June 13, 1922	Sept. 27, 1922	Nov. 17, 1927
Dissolved solids (evap.)	10.90	14.40	12.85	19.70	28.60
Total alkalinity as $CaCO_3$	5.00	9.78	4.36	2.77	12.70
Free carbon dioxide	0.80	0	0.80	0	0
Calcium	0.36	0.25	0.67	0.50	3.70
Magnesium	0.61	0.12	0.34	0.74	8.90
Sodium	4.07	8.64	2.57	1.15	2.57
Carbonate	0	4.34	0	1.37	1.70
Hydroxide	0	0	0	0.60	0
Bicarbonate	6.10	3.10	5.32	0	1.38
Sulphate	4.94	5.59	2.63	1.98	9.55
Chloride	1.40	2.91	1.21	1.29	0.91
Nitrate	0.18	0.22	0.07	0.18	0.02
Ignition, loss	1.30	4.05	3.20	1.20	4.43
Silica	0.50	0.50	1.00	3.55	2.55
Oxides—iron and aluminum	0	0.95	1.00	0.45	0.15

side of the pad only. Excessive calking marks were observed on the pad edges. No cracks were found in the mud-drum sheet. The observed cracks are shown diagrammatically in the plan-view of Fig. 1. The continuous crack on the left edge was caused when removing the pad; this distortion prevented making measurements to show the discrepancy in curvature.

A section to be examined miscroscopically was cut from a portion of the flange showing discontinuous cracks between rivet holes. It was so cut as to include a specimen between rivet holes, to expose the metal contacting with and tangent to the shanks of the rivets. This is shown in the isometric view of Fig. 1, with surfaces *A*, *B*, and *C* marked to correspond with the indications on the plan-view.

The exposed specimen was roughly polished, and photographed unetched; the three surfaces being shown in Fig. 2 with explanatory notations. The major cracks

TABLE II—ANALYSES OF CONCENTRATED BOILER WATER

	June 7, 1924 Boiler No. 53 p.p.m.	Nov. 17, 1927 Boiler No. 31 p.p.m.
Dissolved solids (evap.)	1,060	5,417
Total alkalinity as $CaCO_3$	310	1,657
Calcium	10	4
Magnesium	0.5	1.6
Sodium	371	2,003
Carbonate	26	128
Hydroxide	90	491
Sulphate	461	2,356
Chloride	28	183
Nitrate	6	11
Ignition loss	14	38
Silica	16	32
Oxides—iron and aluminum	9	11
Embrittlement ratio = $\frac{Na_2SO_4}{\text{Total Alky. as } Na_2CO_3}$	2.07	1.92

in surface *B* originate at the rivet holes, and progress in two directions, across the drum-contacting surface toward each other, and transversely across the thickness of the sheet, approaching the external, or "dry," surface. Small branch cracks project from the main crack.

Of specific interest are the small cracks that originate at the surface tangent to the rivet shanks, but which do not extend to the outer surfaces of the flange. These are in Fig. 2 on surface *A* at the intersection 11-*d*, and surface *B* in the upper left area, but are not clearly visible in the engraving. These cracks, as shown in the microphotograph *A*-1 (Fig. 3) are in an area of strained crystalline structure.

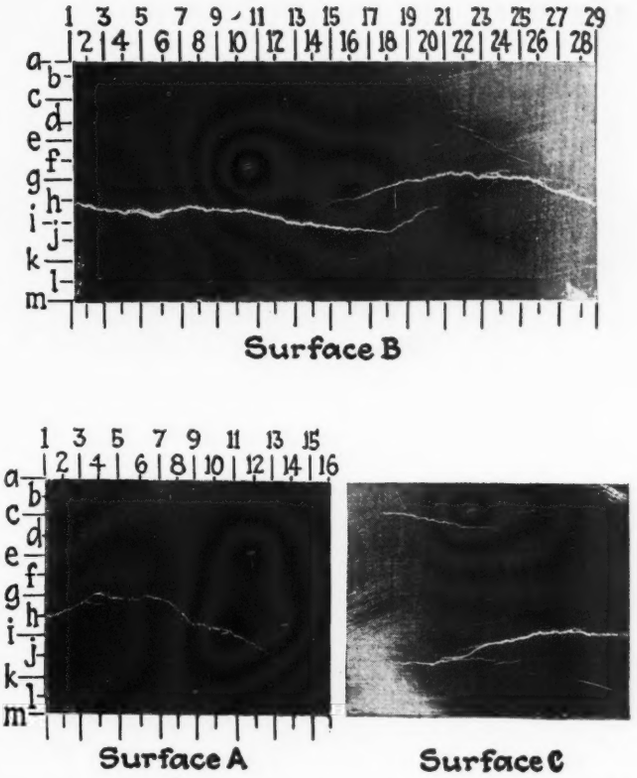


Fig. 2—Macrographs of surfaces A, B *and* C *of sample (see Fig. 1) showing locations of microphotographs (Fig. 3) at intersections of numbered and lettered lines*

Macrographs made at 2.5 diameters (reproduced 1.9) from partly polished surface not etched.

Selected locations in sections *A* and *B* after polishing were etched with 4 per cent Nital and were photographed at 250 diameters. These are reproduced at 180 diameters in Fig. 3, the locations being indicated by reference to intersections in Fig. 2. Photo *B*-1, located at intersection 13-*h*, shows characteristics of fatigue cracking. Photo *B*-2, located at intersection 20-*i*, is similar to *B*-1 but shows less corrosion. Photo *B*-3, at intersection 22-*c*, is similar to *B*-1 and *B*-2 and shows some evidence of strained crystalline grains. Photo *B*-4, at intersection 16-*b*, is similar to *B*-3, with evidence of increased corrosion.

Photo *B*-4*a* is magnified 1,050 diameters (reproduced 750 diameters) in the area intersected by the cross-hairs in photo *B*-4. The corrosion cracks radiate in diverse directions, following both the grain boundaries,

TABLE III—EMBRITTLEMENT RATIOS OBTAINED DURING OBSERVATIONS ON CONCENTRATION ON BOILER 55

(Embrittlement ratio = $\frac{Na_2SO_4}{\text{Total Alky. as } Na_2CO_3}$)

	Ratio	
1919		
Nov. 18	[1]1.76	
Nov. 23	2.92	Average 2.69 during run of 19 days and a total evaporation of 20,000,000 lb. water.
Nov. 28	3.41	
Dec. 1	2.79	
Dec. 6	[2]2.70	
Dec. 9	[1]1.72	Average of 3.04 during run of 39 days and a total evaporation of 39,000,000 lb.
Dec. 14	1.90	
Dec. 19	1.96	
Dec. 24	2.76	
Dec. 29	3.38	
1920		
Jan. 3	3.61	
Jan. 8	4.02	
Jan. 13	4.33	
Jan. 16	[2]3.70	
Jan. 20	1.51	Average of 2.60 during run of 14 days and a total evaporation of 13,875,000 lb.
Jan. 25	3.46	
Jan. 28	2.90	
Jan. 31	[2]2.55	

[1]First day of run. [2]Last day of run.

and projecting into the crystalline grains themselves.

All the photographs of series *A* exhibit marked grain deformation, due to strain. The photographs show a greater carbon content than in series *B*. Photos *A*-1, *A*-2, and *A*-3 show corrosion cracks following the general direction of the strained crystalline grains. Photo *A*-4 was taken in a location where no crack was visible. This photograph shows strained crystalline grains, and no cracks.

Conclusions

The authors conclude from the observed data, that:

1. The cracking of the pad is due to corrosion and strain.
2. Strains were set up in the metal when the pad was originally applied to the drum. These included bending and distortion and riveting pressures, all classified as cold working. The strains were aggravated by working stresses induced during the eight years of operating service of the boiler.
3. Strains and segregated impurities in the metal accelerated corrosion when water penetrated into the space between the rivet shank and the rivet holes.
4. Lack of inside calking of the pad permitted leakage between the rivet shank and rivet holes.
5. The concentrated boiler water possessed a ratio adequate to inhibit embrittling action.

A Routine to Encourage Betterment Recommendations

By Walter N. Polakov*
Consulting Engineer, New York City

A MAN worthy of his hire is one who thinks about his job and feels the lure of perfection. Such a man often has valuable suggestions to make, but, having no regular channel through which to submit them, neglects to put forward his ideas.

In order to avoid such losses, it is suggested that a definite routine be established by means of which these recommendations will be encouraged, studied and approved, or not approved, and, after approval, track kept of the results attained.

This article is an outline of such a practice, and describes the handling of betterment recommendations or trouble reports.

Purpose: The purpose of written recommendations for betterment may be: (*a*) Asking authority, (*b*) requesting co-operation, (*c*) comparing expectations with accomplishment, (*d*) watching the progress of work.

Writing Recommendations: Special blanks should be available to all employees upon which recommendations for betterment of equipment, process or method may be made. It should clearly and briefly state:

1. Where and when loss occurs.
2. How it occurs or who or what causes it.
3. Suggested means for prevention of loss or danger.
4. Approximate estimate of time or money saved, if recommendation is put into effect.
5. What it will cost to make the improvement.
6. Signature of the one making the suggestion.
7. Date when written.

Examination: The recommendation should then be sent for examination to the proper authority, and, if approved, the following entries made:

1. Signature of approval.
2. Symbol of department affected by the plan.
3. Charge account and work order number.
4. Date when approved for execution.

It may then be referred to the department head or superintendent authorized to proceed with the proposed betterment.

Responsibility: The executive approving the recommendation assumes the responsibility of securing results. He keeps the copy of the recommendation on the monthly "tickler" and follows up the results from operating or accounting department reports.

Generally these recommendations are taken care of by one of the three departments: Office manager (improvements in office routine or equipment), plant engineer (improvement in equipment), production manager (improvements in practice).

Record of Progress: When work is started according to a new plan, the form should be dated "work started," and on the back of the form data from the *past* operating performance noted for future comparison.

When the installation of a new method is completed the recommendation should be dated "work completed" and returned to the executive approving the change. Monthly entries should be made on the back of the form showing important operating data obtained under the new conditions, in order that comparisons may be made with the old practice previously marked on top.

RECOMMENDATION

ESTIMATED NET SAVING $_____ PER YEAR / MONTH / DAY

CHARGE TO ORDER

Location of Loss or Inefficiency, _____

How It Occurs; _____

Method to Prevent It; _____

Estimated Gross Saving; _____

$_____

Probable Cost of Accomplishment; _____

$_____

Suggested By _____ Approved By _____

WRITTEN			OK FOR EXECUTION			WORK STARTED			WORK COMPLETED		
Month	Day	Year	Month	Day	Year	Month	Day	Year	Month	Day	Year

Form to be used in making suggestion for improvements

When the new practice is well established (depending on its nature) a comparison is made as to actual results attained. Then acknowledgment or a reward may be made to those whose recommendations were successful, i.e., saving was equal or in excess of the estimated saving.

*All rights for republication or other use retained by Walter N. Polakov.

How the HEAT-WORK DIAGRAM *Solves Air-Compression* PROBLEMS

These diagrams, as yet not widely known, can be used to find the heat-equivalent of the power rate without the use of an indicator diagram. They can be used for any gas or vapor of which the thermal properties are known, and they permit a close analysis of heat flow and energy conversion. The air chart, published on page 518 of the Oct. 1 number of* POWER, *facilitates their application to air compression problems.

BY W. S. HUNTINGTON
Author of "Graphic Thermodynamics"

ENGINEERS are familiar with the ordinary indicator diagram and with the method used to find from it the indicated horsepower of a compressor or an engine. There is another method, not as yet widely known or used, by which one may learn the heat equivalent of the power rate without the use of an indicator. The two methods give, theoretically, equal results. The "instrument" required for this second method is a simple, easily constructed diagram which one can draw in a few minutes in the office or the engine room. It is what the writer has called the "heat-work" diagram. The indicator diagram is concerned with pressures and volumes, but not with temperatures; in other words, it may be taken, and a power rate determined therefrom, without any definite knowledge of the initial or final temperature of the gas or vapor within the cylinder, or any of its thermal properties.

On the other hand, the essential data for a heat-work diagram are definite knowledge of the thermal properties of the air, gas, or vapor, and of the initial and the final temperatures and pressures. By thermal properties is meant those listed in steam tables and ammonia tables, or charted in the various air, steam and ammonia charts; that is, total heat content, entropy, pressures, volumes, etc. In addition, for this purpose, the charts or tables preferably should show the internal energy content as at various pressures and temperatures. The air chart which appeared on page 518 of the Oct. 1 issue of *Power* is suitable for use in the solution of problems in air compression or expansion. Initial temperature, when this term is used in connection with the heat-work diagram, means the temperature of the air or gas in the cylinder at the instant when compression thereof actually begins, or, in the case of the air or vapor engine, at the instant of cut-off, when expansion begins. Final temperature is, in the compressor, that of the air or gas at the end of the compressive fraction of the piston stroke, just before the opening of the discharge valve. In an expansion cylinder, as of an engine, it is that which obtains at the end of the expansion, before opening of the exhaust valve.

Truly, it is not an easy matter to determine with accuracy the initial and final temperatures as here defined, but, ordinarily a fairly close estimate of temperatures can be made. For construction of the diagram one needs only pencil and paper, a straight-edge ruler, a decimal scale and some means for laying off right angles. The last-named item and the scale may be dispensed with if one uses quadrille-ruled paper. A description of the method for simple problems in air compression and expansion follows:

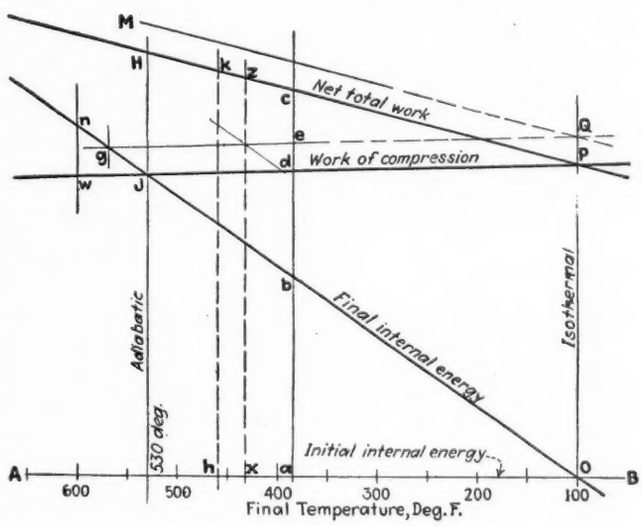


Fig. 1—Compression diagram

We shall take, first, a case in single-stage air compression, assuming an initial pressure in the cylinder of 13.5 lb.; initial temperature, 100 deg.; final pressure, 98.8 lb.; and final temperature, 385 deg. (All temperatures Fahrenheit, all pressures in pounds per square inch absolute. Using the air chart mentioned in the preceding paragraph, or any chart of the same scope, we find that if the compression were adiabatic the final temperature would be 530 deg., and that the gain in internal energy and the expenditure of total heat accompanying the increase of 430 deg. in temperature would be 73.6 B.t.u. for the former, and 103.2 B.t.u. for the latter. Next we compute the work, in B.t.u. equivalent, for isothermal compression at 100 deg. constant temperature, and find that it would be 76.6 B.t.u. We now have the data necessary for the

diagram, shown as Fig. 1. First, the horizontal line *AB* is drawn, and a scale for temperature marked thereon; then the vertical lines through points marking the initial, the actual final, and the adiabatic final temperatures (that is, 100 deg., 385 deg., and 530 deg.); then on the initial temperature vertical we lay off, measuring upward from *AB*, the B.t.u. equivalent of the work as required with isothermal compression, 76.6, to any convenient scale, thereby determining the location of the point marked *P*; on the adiabatic temperature vertical we lay off similarly the internal energy gain, 73.6 B.t.u., thus determining point *J*, and total heat used, 103.2 B.t.u., determining point *H*. These several heat quantities, it should be made clear, are those required for one pound of air. The pound is the unit weight assumed for any heat-work diagram. Having thus fixed the governing points, we draw the straight lines *JO*, *JP*, and *HP*, and have the diagram, in its basic form. To find the heat equivalent of the power required for compression to any final temperature, simply measure the distance between *AB* and *HP* on the vertical line for that temperature. Thus at 385 deg., scale the distance *ac*, which is found to be 94.3 B.t.u. This is the heat equivalent of the power required to compress and expel from the cylinder of a compressor one pound of air, under the set of conditions assumed for the problem. If the final temperature were, instead, let us say, 460 deg., then one would scale the power required on the vertical drawn at the 460 deg. temperature, that is, at *hk*, 99.0 B.t.u. At 250 deg. it would be 86.0 B.t.u.; etc.

Finding Horsepower From Heat Equivalent

To convert work as thus found in B.t.u. into equivalent horsepower, we must know the number of pounds of air compressed in a given length of time, preferably in one minute of time. One horsepower is the work equivalent to the energy of 42.45 B.t.u. of heat used per minute, and using this factor one can readily convert the result as read in heat units into the more familiar power units. For instance, suppose that 4 lb. of air is handled per minute, with 385 deg. final temperature. The required power is $\frac{94.3}{42.45} \times 4 = 8.89$ hp. Again, if the final temperature were 460 deg. the power rate would be $\frac{99.0}{42.45} \times 4 = 9.33$ hp. If one should use an indicator on compressors working at the conditions stated, and determine the indicated horsepower from the diagrams taken therewith, the results should agree closely with those here determined. The heat-work diagram method, it may be noted, requires no knowledge of cylinder dimensions or of revolutions per minute. Whereas the indicator diagram shows what work is actually done in a particular machine on a certain volume of air while effecting a known change in its unit pressure, the heat-work diagram shows, conversely, not work done by a machine, but what work must be done on a certain weight of air to effect a specified change in its temperature and unit pressure. One method deals with the compressor—a machine; the other with the substance compressed. Results found by the two methods should, theoretically, be identical, and in actual practice should agree closely.

Partial information concerning the quantity of jacket water needed may be obtained from the diagram. In Fig. 1 the quantity *bd*, 26 B.t.u., is the heat lost from a pound of air in the course of the compressive half of the piston stroke. Heat also passes from the air in the expulsive half of the stroke, but that loss does not affect the net power requirement and therefore does not appear in the diagram; it may amount to 40 to 60 per cent of the loss as scaled from the diagram. An unknown portion of the total heat loss is that due to radiation, but the greater portion passes to the water circulated through the water jacket. Neglecting radiation and assuming that the entire loss is to water, one can easily calculate the quantity of water required for a given case.

Increase in internal energy is measured by the distance between *AB* and *OJ* on a vertical line through the final

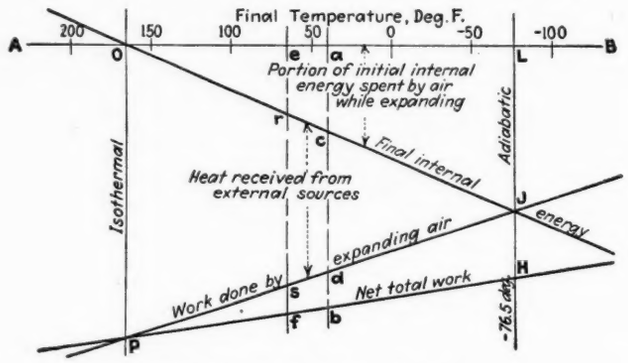


Fig. 2—Expansion diagram

temperature point. The loss of heat, as already stated, is measured between *OJ* and *JP*. The difference between the work required for expulsion of a pound of compressed air from the cylinder and the useful work done by another pound of air that enters the cylinder from without at the same time is measured between *JP* and *HP*. The sum of these three items is the net total work. Final temperature cannot be higher than the adiabatic temperature unless heat is received from an outside source during all or part of the compressive part of the stroke. For instance, Fig. 1, if the final temperature were found to be 600 deg. it would signify that the quantity of heat *wn* had come into the air from an outside source.

One outside source of heat is always present and active in compressor operation; that is the heat of piston fric- and expulsion, possibly four per cent or more. The addition is practically constant at all final temperatures and may be accounted for in the diagram. For the case of Fig. 1 we may estimate the piston friction as 7 B.t.u. per pound of air (roughly, 7 per cent of net total work). With inclusion of this, the compression line rises to *gQ*. that for net total work to *MQ*. Now if no heat were carried away by jacket water or radiation the final temperature would be that measured by the vertical through point *g*, about 569 deg. At any final temperature the loss to jacket water and by radiation is increased by the piston friction. At 385 deg. it is *bc*, whereas without friction it would be *bd*. Obviously, in case the quantity *bc* is greater than can be received by the jacket water, radiation, etc., then the final temperature cannot be as low as 385 deg.; final temperature is controlled by heat loss. If the total heat-receptive capacity of water and radiation should be 36 B.t.u., let us say, and three-fourths of this can pass during the compressive part of the stroke, then a line drawn parallel to and 24 B.t.u. above *OJ* will cut *gQ* at the final temperature which must obtain, 433 deg., and the heat equivalent of the

necessary indicated horsepower can be measured at *xs*.

It should be explained that to make the diagram mathematically accurate the lines *JP* and *HP* should be flat curves instead of straight lines. The true curves, were they to be drawn for comparison, would lie scarcely more than the width of a pencil line away from (and above) the straight lines, hence the error resulting from use of the latter is small, never as much as 1 B.t.u. with the pressure ratios practicable for one-stage compression. For the common ratios and final temperatures it is less than 0.6 B.t.u.

Diagrams Useful in Multi-Stage Compression

Heat-work diagrams are useful in studies and analyses of multi-stage compression. A separate diagram may be made for each stage, or they may be combined, as one may prefer. With their aid one can determine quite

> "Whereas the indicator diagram shows what work is actually done in a particular machine on a certain volume of air while effecting a known change in its unit pressure, the heat work diagram shows, conversly, not work done by a machine, but what work must be done on a certain weight of air to effect a specified change in its temperature and unit pressure. One method deals with the compressor—a machine; the other with the substance compressed. Results found by the two methods should agree closely."

definitely and quickly the effects in power requirement of variations in the several factors involved, such as final temperatures, efficiency of water jacketing, frictional heat, drop in pressure at inlet valves, inlet heating, intermediate pressures, and intercooling.

Fig. 2 is a simple diagram for expansion of air in a compressed-air engine. The conditions for which it is drawn are: Initial pressure in cylinder, 110 lb.; initial temperature, at instant of cut-off, 165 deg.; final pressure, 20 lb. The quantities one must compute or determine from chart readings are: The adiabatic final temperature, found to be —76.5 deg. (which locates *L*); the work that would be done by a pound of air expanding isothermally at 165 deg., found to be 73.0 B.t.u. (to be represented by *OP* in the diagram); the decrease in internal energy at the adiabatic point, 41.3 B.t.u. (which will fix the line *LS*); and the change in total heat at adiabatic, 57.8 B.t.u. (which will fix the line *LH*). Having thus located the five governing points, we draw the connecting straight lines *OJ*, *PJ* and *PH*. Now, for any final temperature, scale the work done by the engine between the lines *AB* and *PH*. For instance, if the final temperature is 40 deg. the work done by the engine is 65.3 B.t.u., measured by *ab*.

The diagram permits comparison of the gains in power resulting from the addition of various quantities of heat to the expanding air from a steam jacket or other source. For example, the reception of 35.2 B.t.u., as at *cd*, determines the final temperature as 40 deg. A lesser quantity of heat received would result in a lower final temperature; a greater quantity, in a higher temperature. If each pound of air could take 42.8 B.t.u. of heat, the quantity measured by *rs*, the final temperature would be brought up to 65 deg., and the net total work to 66.8 B.t.u. (*ef*), which is 1.5 more than that measured by *ab*, showing clearly that the addition of 7.6 B.t.u. from the steam jacket effects a net gain of 1.5 B.t.u. in work done; that is, in power.

The lines *JP* and *HP* should, in fact, be flat curves, with convexity downward, but the error incident to use of straight lines is negligible. A computation by the standard formulas for the work done at a final temperature of 40 deg., example of Fig. 2, yields 65.65 B.t.u., only 0.35 more than the scaled value. An error of this order does not materially affect the result as converted into equivalent horsepower per pound or per 100 cu.ft. of air.

Piston Friction Lines May Be Added

Lines for heat of piston friction may be added, if desired. They will lie above the lines for expansion and for net total work and mark the decrease in effective work done by the air. Heat of piston friction, or at least that part of it which passes into the expanding air, is heat from an "outside source" and tends, in small measure, to increase the power yield.

Those who have had occasion to apply the standard formulas (as found in engineering handbooks or in works on thermodynamics) for finding the power required for air compression, or returned by air expansion, for final temperatures other than the adiabatic or the isothermal, are familiar with the ratio expressed in the formulas by the symbol *n*, and with the work necessary for finding that ratio for a given case. This troublesome *n* is obtainable quickly from the heat-work diagram, but it is not necessary for use with the diagram. In the case of Fig. 2, at 40 deg. the ratio *n* is simply the ratio of *ab* to *ad*; that is, $\frac{65.3}{56.7} = 1.151 = n$. For the case of Fig. 1, 385 deg. final temperature, $n = \frac{ac}{ad} = \frac{94.3}{74.7} = 1.262$. Always it is the ratio of the net total work to the work of the compressive, or the expansive, portion of the piston stroke.

The value of a heat-work diagram to any user depends on the degree of accuracy with which the governing conditions (temperatures and pressures) have been determined. If these are correct he has a criterion to which he may compare the actual performance of the compressor or engine, any excess of power shown by an indicator card above that established as normal by the heat-work diagram shows a waste of power (such as might be caused by leakage of air past the pistons, valvular defects, etc.) and calls for a careful investigation.

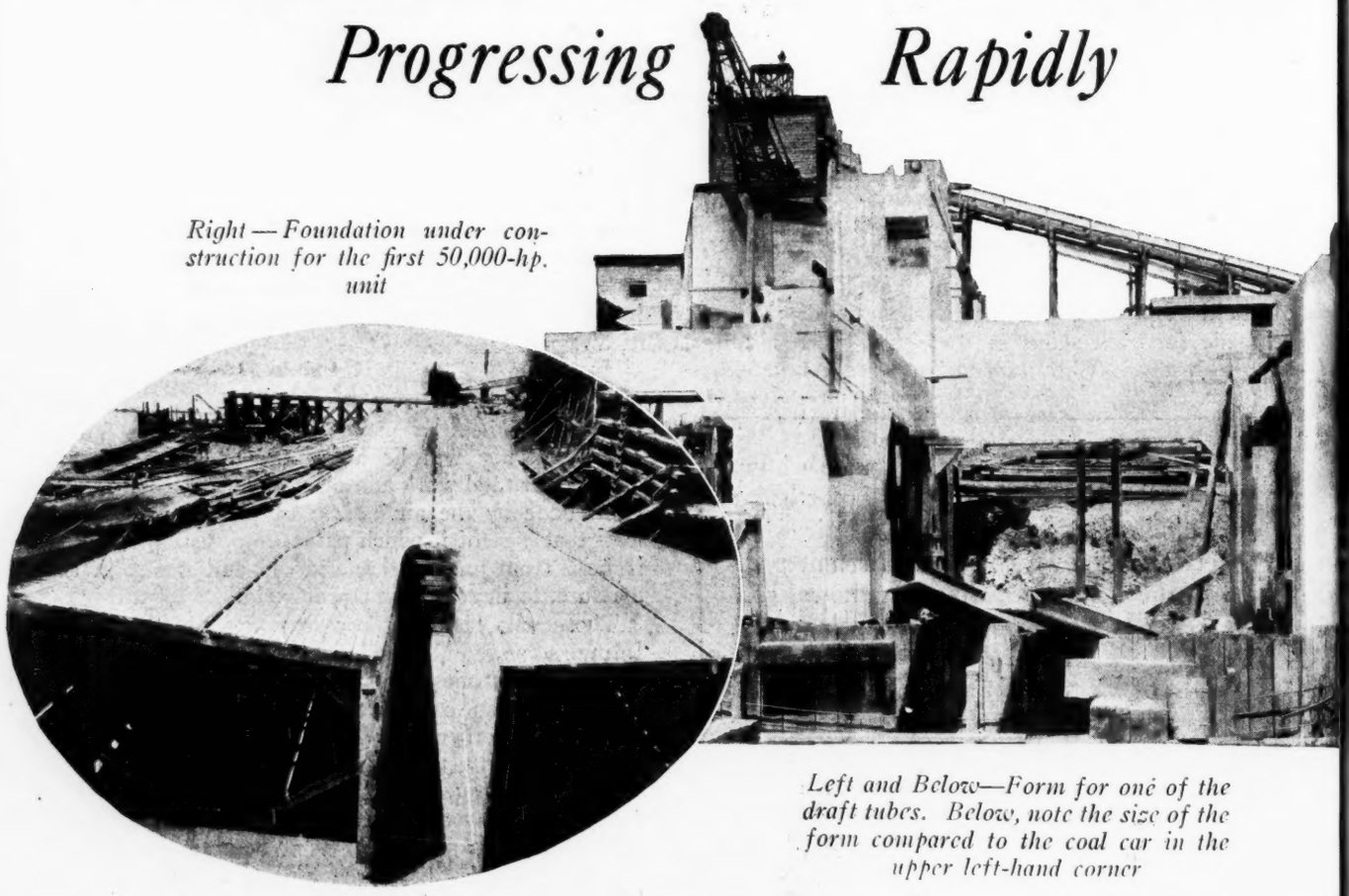
For months interest has centered around the

State Line Generating Station

near Chicago, in which is installed the world's largest turbine-generator. The station was formally opened on Oct. 22, and information has been released concerning the details of the plant. The story will appear in

POWER Next Week

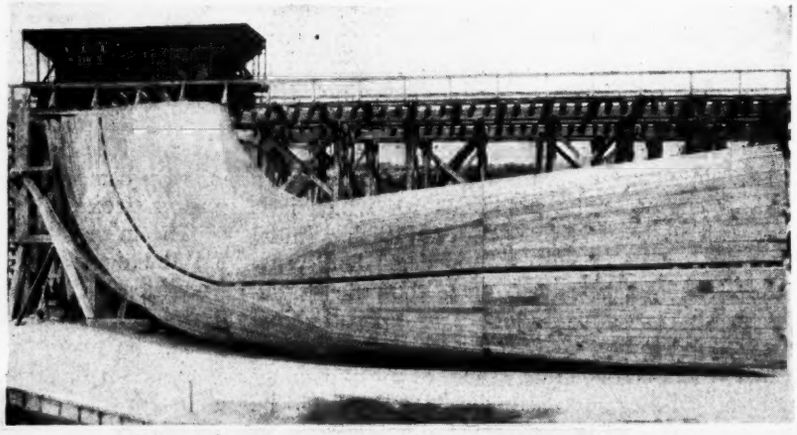
Saluda Hydro-Electric Development Progressing Rapidly

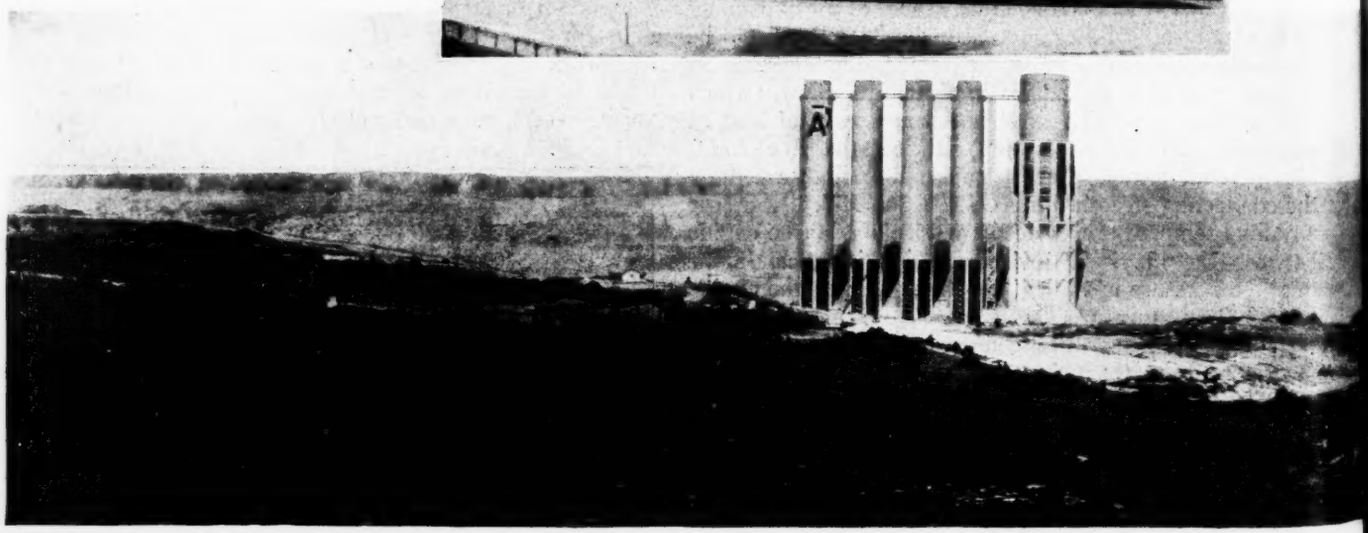


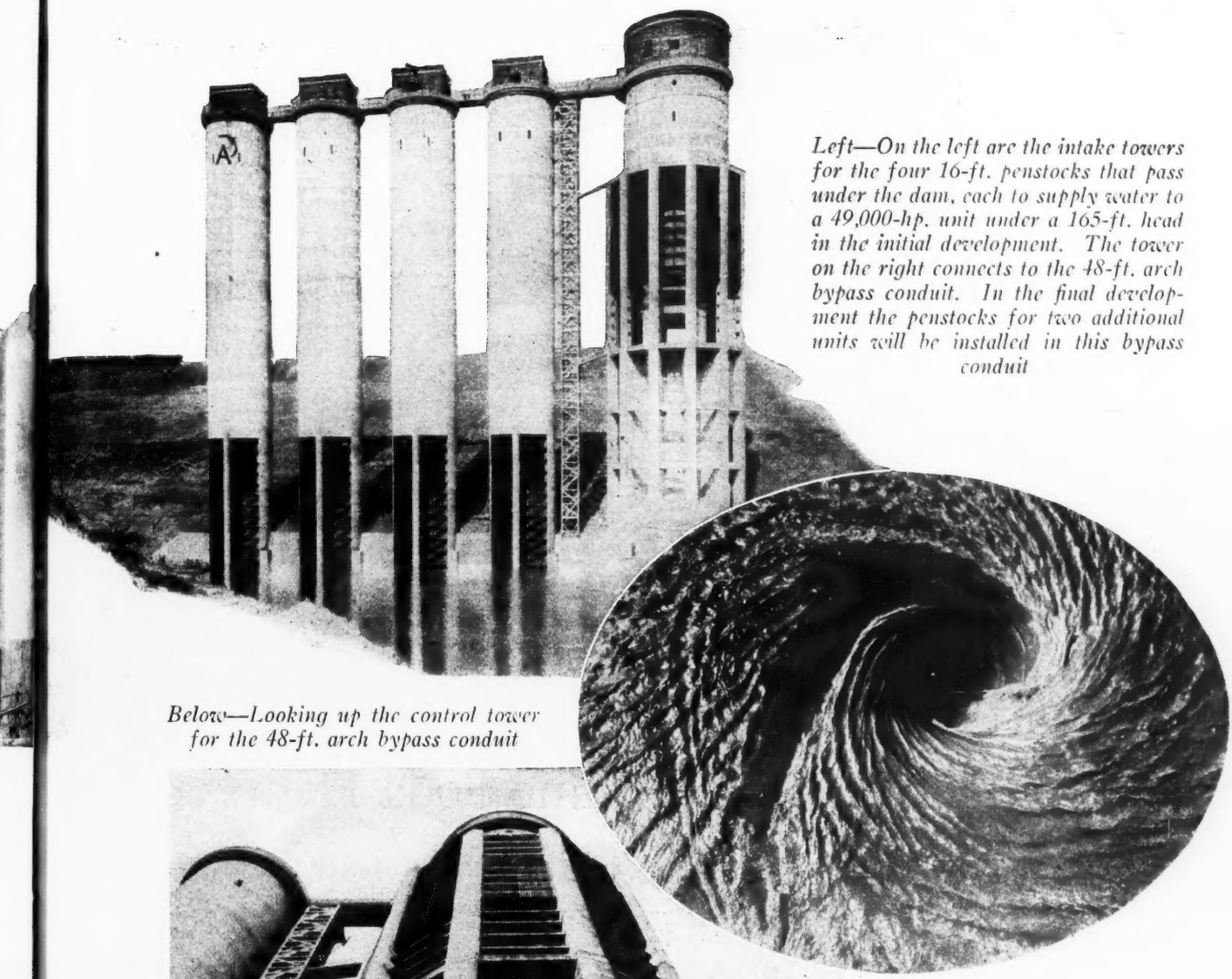
Right — Foundation under construction for the first 50,000-hp. unit

Left and Below—Form for one of the draft tubes. Below, note the size of the form compared to the coal car in the upper left-hand corner

Across the bottom of the two page is a view of the earth dam under construction on the Saluda River near Columbia, S. C., for the Lexington Water Power Company. The final height of the dam is indicated at A on the intake tower. This dam will be 208 ft. high and two pages is a view of the 93 billion cu.ft. capacity



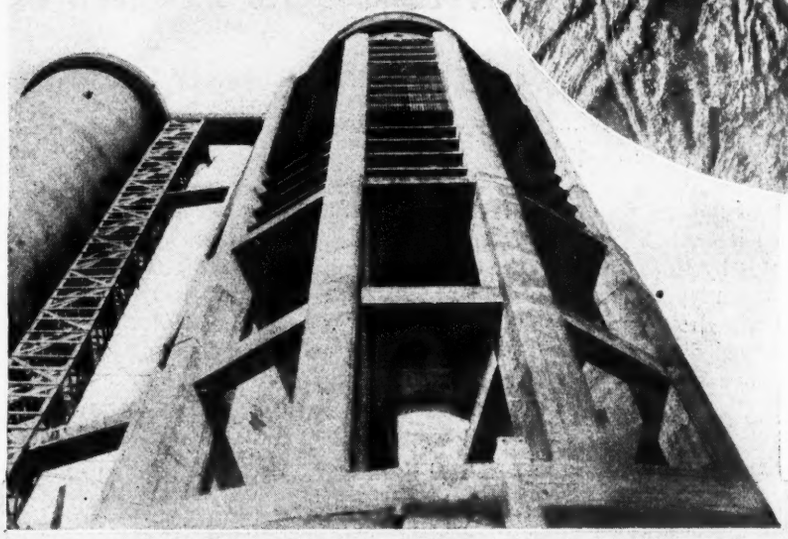


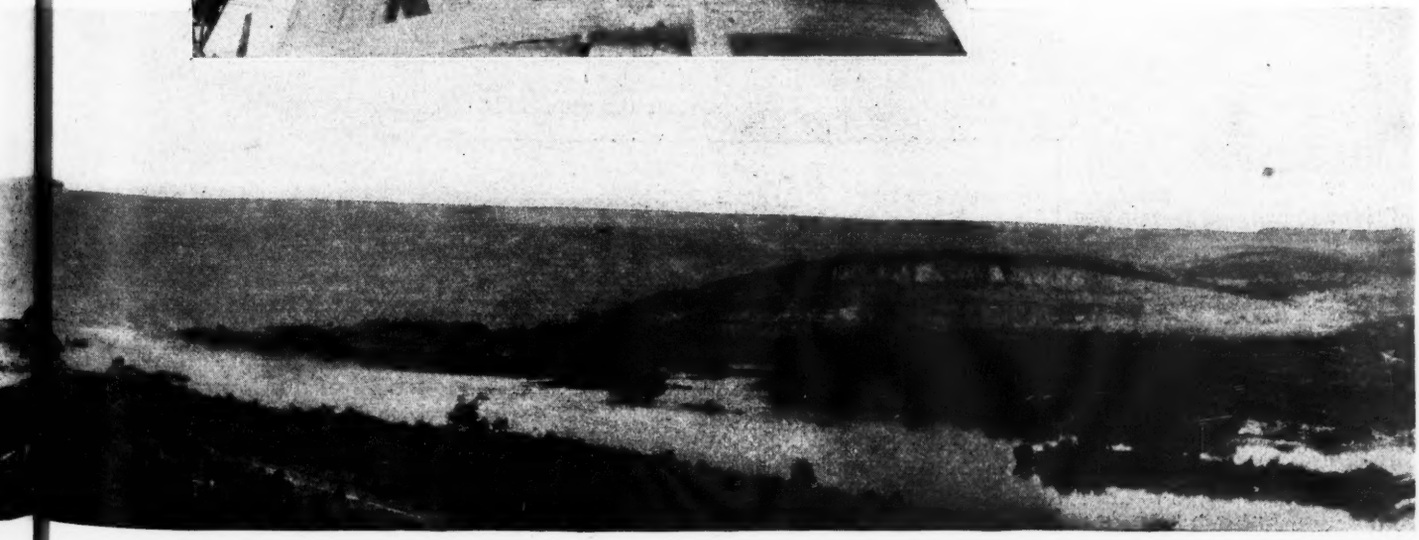


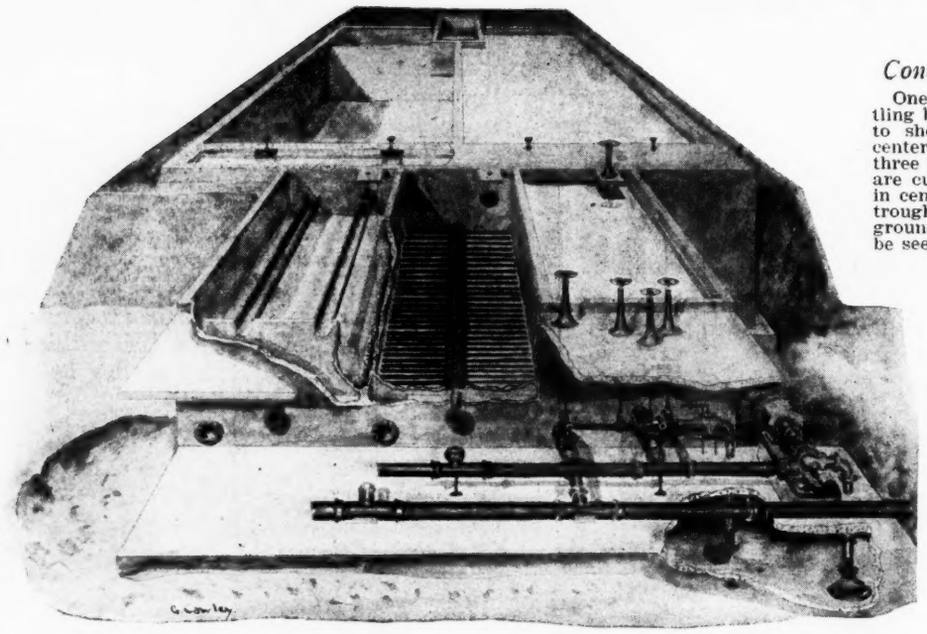
Left—On the left are the intake towers for the four 16-ft. penstocks that pass under the dam, each to supply water to a 49,000-hp. unit under a 165-ft. head in the initial development. The tower on the right connects to the 48-ft. arch bypass conduit. In the final development the penstocks for two additional units will be installed in this bypass conduit

Above—Whirl of the water entering the bypass conduit during a flood. The bypass conduit has since been closed for about six weeks and the reservoir is being filled

Below—Looking up the control tower for the 48-ft. arch bypass conduit







Concrete gravity filtration plant

One compartment of the divided settling basin in the background is empty to show the baffling. Flume across center connects settling basin with three filter units in foreground. Walls are cut away to show strainer system in center unit and filter bed and wash troughs in left-hand unit. In the foreground, beneath the pipe gallery, may be seen the clearwell.

Industrial Water Treatment

I—Filtration and Lime Soda Plants

By GEORGE CAWLEY
Montclair, N. J.

EFFORTS to improve the quality of natural waters have been made for centuries, as instanced in the use of crude aluminum compounds by the Hindus and the Chinese. Of course, until recently, these attempts at purification have necessarily been crude. While an historical account of the gradual development of water filtration and softening would be of great interest, this article will deal only with the present state of the art.

For convenience, the treatment of water for potable purposes, boiler feed and manufacturing, may be divided into three general operations: (*a*) removal of suspended matter and colloidal solids; (*b*) softening; (*c*) sterilization.

The simplest method of removing suspended matter is to allow the water to stand quietly in a tank or basin, the lack of any agitation allowing the fine particles to drop through the water. The clean water is drawn off from the farthest possible point from the inlet, unless the process be worked intermittently, in which case a floating outlet is usually employed to draw the water off just below the surface. Very fine particles, especially in the presence of colloidal and organic matter, do not settle out very fast, if at all; unless they are absorbed on the heavier, solid material, the colloidal material remains in the water and gives it what is known as "color."

"Turbidity," or suspended solid matter, is distinguished from color by its opacity. Bottoms of streams whose waters are colored may be visible to considerable depth, but the water will exhibit various shades of yellowish brown up to that of cold tea. The soft waters of New England streams often have this color characteristic.

For the removal of fine turbidity and color an insoluble precipitate is formed in the water to be treated, so that the impurities can either be caught mechanically or absorbed. The gelatinous flocculent hydrate of aluminum is the most accepted medium for this purpose. Other similar hydrates are also used, the alum hydrate being formed by mixing with the raw water a solution of aluminum sulphate or one of the crystal alums, such as potassium or ammonium-aluminum sulphate. The natural alkalinity in the raw water effects the reaction

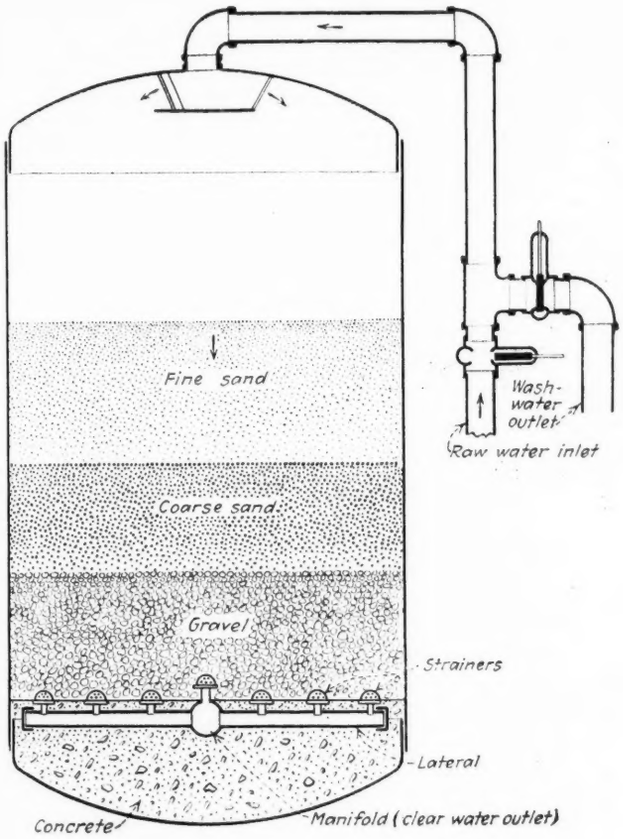
The boiler-feed problem often involves the general question of treating water for all plant uses. This is the first of two articles dealing with the subject broadly but in a practical manner. The concluding article will take up zeolite softening and other types of treatment.

in accordance with the following chemical formula:

$$3\ Ca\ (HCO_3)_2 + Al_2\ (SO_4)_3 \leftrightarrows 3\ Ca\ SO_4 + 2\ Al\ (OH)_3 + 6\ CO_2$$

Where there is not sufficient alkalinity for this reaction, solutions of suitable alkali are added, the most common reagent being soda ash. Where sulphate of iron, the ferrous salt, is used instead of alum, lime is necessary to produce the precipitate or "floc." The lime is fed in the form of a suspension, or "milk." The operation of producing a flocculent precipitate in the raw water is known as coagulation, and the chemicals are called coagulants.

Coagulants may be applied to the raw water at the entrance to a settling basin or just prior to filtration. Filtration involves passing the water through a porous medium the interstices of which are small enough to prevent the passage of the suspended materials. This definition is subject to modification, as we shall see later,



Sectional elevations of typical pressure sand filter

but it will do to start with. In water rectification the usual porous medium is a bed of silicious sand, although for household and similar purposes, special papers, stones and charcoal are often employed.

The sand bed is composed of carefully screened sand, as a rule, in layers of different sizes, the finest being at the top. The sand bed is supported on a series of gravel layers, fine at the top and coarser at the bottom. This arrangement of increasingly larger material forms channels for the easy drainage of filtered water; and keeps the caught impurities at the top of the bed, for the water passes downward.

The graduated arrangement of sand and gravel layers is necessary to prevent sand coming through with the filtered water, as the size of each layer is so chosen that its interstices are small enough to prevent the passage of the particles of the layer just above it. The graduated arrangement is that which the bed would naturally take after being washed, since the cleansing of the bed is accomplished by reversing the flow of water.

Washing the bed by forcing water upward through it will be seen to be the logical method, since the cleanest water is in contact with the cleanest portions of the bed; the heaviest accumulation of mud is at the upper surface of the sand bed and thus can be carried away without mixing with much of the sand bed. Another, and most important, reason for washing the bed upwardly is the fact that the upper portion of the unconfined bed rises with the water and is broken up, the sand grains, swirling around, rub together and are thus cleansed mechanically. The wash water with the mud it has removed is wasted after leaving the filter. In a few exceptional cases this used wash water is allowed to stand in settling basins and the clear water used over again for washing.

In commercial installations where the raw water is not very dirty, it may be used for filter wash water; but in well-designed plants for supplying communities with potable waters, the use of filtered water for washing is obligatory.

The sand grains in the upper layers of the filter accumulate a gelatinous coating, which greatly aids the bed in removing fine material from the water. This coating may be alum floc from a coagulated water; it may be deposited from an iron-bearing water; or it may be of organic origin and similar to the familiar slimy coating on rocks submerged in lakes and streams. When this coating has built up on the sand grains, the bed is said to be "seasoned." Where the raw water is properly coagulated, the coating on the sand grains forms a more or less continuous film on the top of the bed sufficiently effective to remove all but a small percentage of the bacteria in the raw water. Well-designed filters are guaranteed to remove 97 per cent of the bacteria in raw water.

Filtration is also employed to purify well waters containing iron. In such waters the contamination is usually in the form of ferrous bicarbonate and requires a comparatively large amount of free carbon dioxide to keep it in solution. Such waters are often perfectly clear when drawn, but a reddish, cloudy precipitate will form in them on standing. This is due to the loss of some of the carbon dioxide and also to the oxidation of the iron, ferric hydrate being formed.

Obviously, some sort of treatment is necessary on iron waters of this character before filtration, in order that the iron may become insoluble, and so removable by the sand bed. Aeration, treatment with alkalies, or both, are employed to render the water suitable for filtration. Trickling the water through coke beds, running over steps or spraying are the generally accepted methods of aeration. Lime hydrate or caustic soda are the usual alkalies. Sometimes treatment with alkalies follows aeration, the aeration cutting down the cost of chemicals and the alkali finishing the precipitation of the iron.

Sometimes an ordinary filter when "seasoned" will remove iron when the contamination is not great and the water does not contain too much free carbon dioxide, because the iron adhering to the sand seems to have a catalytic effect upon the iron in solution, causing it to precipitate in the filter. In a similar way, iron precipitated on the filling of a coke aerator speeds up the aeration.

Soft, colored waters are difficult to filter; careful ad-

justment of coagulants, proper reaction time, and proper filter rates are required. It is generally necessary in a case of this sort to keep the pH value of the water low, that is to say, on the acid side, until filtration is complete. Such a water is apt to prove corrosive to pipe lines, heaters and boilers; and will reduce the efficiency of some types of zeolites. Therefore additional alkali should be added after filtration to increase the pH value of the water; in other words, render it more alkaline.

Water Softening

Water softening is the removal of objectionable dissolved impurities from the raw water, varied means having been devised to accomplish the desired result. A hard water causes its presence to be known by leaving scale in boilers, sticky soap curds on laundry and textiles, spoiling dye work and generally annoying the householder.

Natural waters might be expected to carry anything in solution as a result of having passed through or over the ground or both; and no doubt a great variety of substances in trace amounts will be found in natural waters. Those substances found in the largest amounts are salts of calcium, magnesium and sodium; iron and manganese occurring, as a rule, in lesser amounts. Of course, alumina and silica are present. The acid radicles usually attached to the above metals are bicarbonate, sulphate and chloricle, with occasional smaller amounts of nitrates or nitrites. If animal contamination is more recent, ammonia will be present.

The grave offenders from the hardness point of view are the calcium and magnesium salts. Iron also curdles soap and adds to scale, but its amount is usually so small in comparison to the other two that it is not usually spoken of when discussing hardness. Where hardness is determined by the soap method, the iron is included in the total hardness and reported as calcium. Sodium salts in large amounts cause troubles which will be explained when we come to zeolites.

The bicarbonates of calcium and magnesium are known as temporary hardness, sulphates of these metals being called permanent hardness. These terms are derived from the fact that a certain amount of free CO_2 is necessary to keep the bicarbonates in solution. Removal of the dissolved gas by aeration, heating or neutralizing causes the formation of the carbonate which will precipitate. It may be noted at this point that magnesium carbonate is much more soluble than the calcium salt, this being dwelt on further under lime-soda reactions. Considerable heating under pressure is necessary to render the sulphates insoluble.

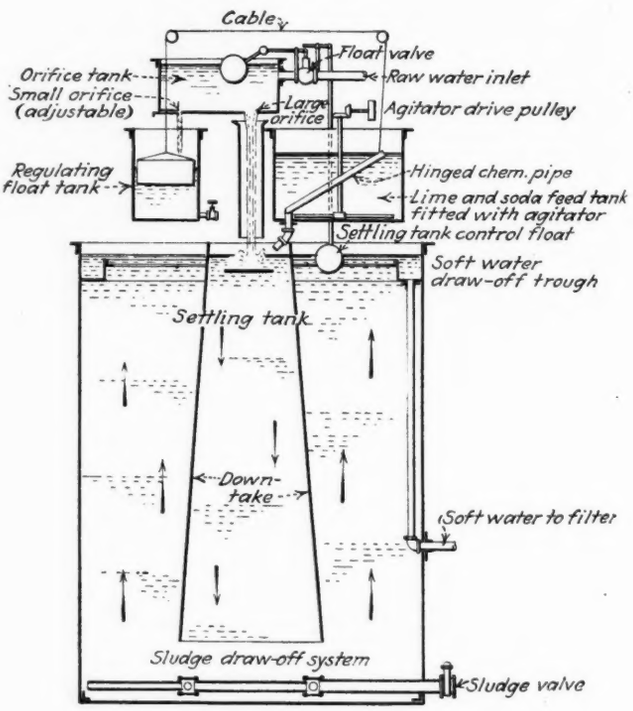
The removal of dissolved impurities may be effected by the use of soluble reagents, "insoluble" reagents and by distillation. The use of soluble reagents was the first large-scale method of softening; and so the various lime-soda, barium and caustic-soda processes were developed. These processes were operated both hot and cold, continuous and intermittent; the choice of plant depending upon operating conditions.

The most usual lime-soda plant is the cold-continuous type, one which permits considerable flexibility with a minimum of attention. The water enters a settling tank after passing through metering and mixing devices. The metering device is designed so that it will control the flow of chemicals to the mixing device, where the chemicals are fed to the raw water, the reaction reaching completion shortly after the water enters the settling tank.

The major part of the settling tank is devoted to the removal of the precipitate. Some filtering means are usually provided at the outlet of the tank to remove any fine material left after the settling. Sand filtration is becoming accepted as the best for this purpose, the older type of excelsior or straw filters having been found inefficient and troublesome.

Frequent chemical analyses of the raw water should be made; and the chemical charges adjusted accordingly; or else adjusted to keep the treated water within certain set limits. The feeding mechanism is designed to suit the flow of chemicals to the flow of raw water, assuring reasonably correct dosage at all times.

If the treated water can be used hot, and further



Cold continuous lime-soda softener

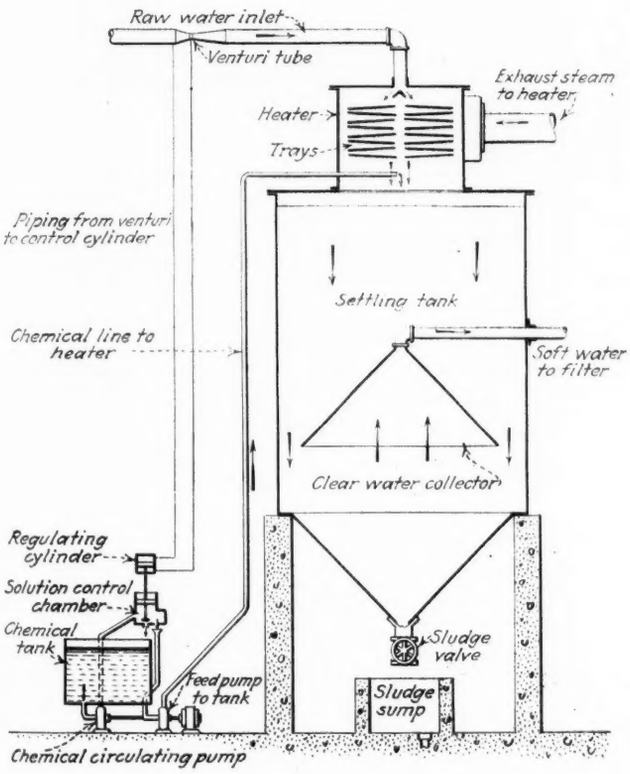
providing that there is exhaust or live steam available, then the plant may be operated as a hot lime-soda plant. Prior to the mixing device the water passes through a heater, of the same construction as the ordinary open feed-water heater, or very similar. Good practice calls for sufficient steam and tray area to heat the water close to the boiling point.

In such operation the water is almost completely degassified, with the result that much of the bicarbonate hardness is thrown down by the loss of free CO_2 from the water. This effects a reduction of the chemical change required. In addition, the residual calcium and magnesium salts are less soluble in the hot water, so that there is a greater reduction in hardness and danger of "after-reactions" is eliminated. After-reactions are the curse of lime-soda treatment. They cause the effluent of cold-process plants to deposit heavy scale in feed pipes, hot-water lines or any place where the water is heated materially above that of the raw water during treatment.

Where the hardness of a source of supply is likely to vary greatly and rapidly, the intermittent type of lime-soda softener has found favor. In this class of plant the water is pumped into a settling tank, dosed with

chemicals, agitated and allowed to settle, the clear water being drawn off through a swinging outlet whose upper end is kept a short distance below the water surface by menas of a float. As a rule, these plants have two or more tanks arranged so that while one tank is being filled, dosed and settled, the other can be drawn from. It is usual to analyze the water from each tankful and make up the chemical batches accordingly.

As the soda reaction in a lime-soda plant does not reduce the total solids, barium compounds have been used where the waters are highly charged with sulphates; lime being used to remove the bicarbonates. Due to the poisonous character of the effluent and the expense of the reagents, this process is not very common. Caustic soda has been used instead of lime. It is easier to



Typical hot-process softener

Note that direction of flow in the settling tanks is the opposite of that shown in the cold-process softener.

feed, but much more expensive. Its use is not very common.

Lime is used in the lime-soda reactions to remove the bicarbonates according to the following reactions:

(1)

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightleftarrows 2\,CaCO_3 + 2\,H_2O$$

(2)

$$Mg(HCO_3)_2 + Ca(OH)_2 \rightleftarrows MgCO_3 + CaCO_3 + 2\,H_2O$$

However, the magnesium carbonate is too soluble to be left in the effluent, so more lime is added to produce the more insoluble hydrate:

(3)

$$MgCO_3 + Ca(OH_2) \rightleftarrows Mg(OH)_2 + CaCO_3$$

Both of the compounds on the right side of the reaction are insoluble. The sulphates are removed by the soda (as carbonate), reinforced, in the case of magnesium by lime:

(4)

$$CaSO_4 + Na_2CO_3 \rightleftarrows CaCO_3 + Na_2SO_4$$

(5)

$$MgSO_4 + Na_2CO_3 \rightleftarrows MgCO_3 + Na_2SO_4$$

Extra lime is used, in the case of magnesium, to produce the hydrate as in equation 3. It will thus be seen that a molecule of magnesium salt requires twice as much lime for removal as does the calcium salt.

To bring these reactions to completion an excess of the reagents is required, the result being a caustic water. The hydroxides left in the effluent of cold lime-soda plants are apt to produce the disagreeable precipitation on heating which we mentioned before as "after reactions"; but if the causticity is neutralized, the trouble is overcome.

Alum sulphate is a usual reagent, because of its acid character, for neutralizing causticity in the water. When using this chemical the reaction is easily controlled, so that just the causticity is eliminated, leaving a small amount of monocarbonate alkalinity in the effluent. The flocculent alum precipitate aids the clarification of the water. Nitrate cake, $NaHSO_4$, has also been used, but it is more difficult to ship, store and handle, as it is much more corrosive than alum. In large softening plants near nitric acid plants, however, the price of nitre cake may make its use advantageous.

[The second and final article, which will appear in an early number of *Power*, will explain the operation of zeolite systems—The Editor.]

A Diesel-Steam Power Plant for R. H. Macy & Company's Store

AS WAS announced in *Power* some time ago, R. H. Macy & Company have purchased two 1,250-hp. Fulton Diesels for operation in conjunction with their present steam plant.

The Macy power plant contains approximately 3,000 kw. in steam engines. These units supply steam for heating in winter and in summer have been exhausting into the atmosphere. Air-conditioning equipment added this year is driven by steam turbines taking exhaust steam from the engines and operating with a condenser pressure of 26 in., which reduces some of the steam loss in summer.

The power load has increased much faster than has the heating load, and it happens that in the summer the steam engine uses steam beyond the needs of the air-conditioning turbines, while in winter some steam passes out into the atmosphere relief lines.

After careful study of all possibilities, such as storage batteries, purchased current, and Diesel engines, the company officials found that an excellent heat balance, both thermally and economically, could be obtained by a combined Diesel-steam plant. The oil engines will be operated under a load such that the remaining load carried by the steam engine will call for just enough steam for heating and for the exhaust-steam turbine.

The engine will be installed early in 1930, and *Power* has arranged for a comprehensive story on the engineering problem involved and the actual performance obtained. This will be published as soon as representative operating figures can be obtained.

OIL SWITCH LIFT RODS

Made of Improved Material

By E. K. READ
Circuit Breaker Engineer
Westinghouse Electric & Manufacturing Co.

Oil circuit breaker lift rods formerly made of maple, hickory or ash are now being constructed of a synthetic wood to obtain greater strength, a more uniform material and to decrease the difficulties caused by broken rods.

A CAUSE of the greatest number of cases of trouble in oil circuit breakers has been the failure of the lift rod. The lift rod must be a good insulator; and in the past this automatically limited the materials that could be used to those of more or less doubtful mechanical strength.

The failure of a lift rod in a three-pole oil circuit breaker may impose dangerous operating conditions on generators or motors. Single-phase operation is one of the results from broken lift rods that may cause considerable damage to apparatus unless detected quickly by the operator. In this case it is frequently difficult to determine the particular breaker that caused the single-phase operation without making several breaker operations.

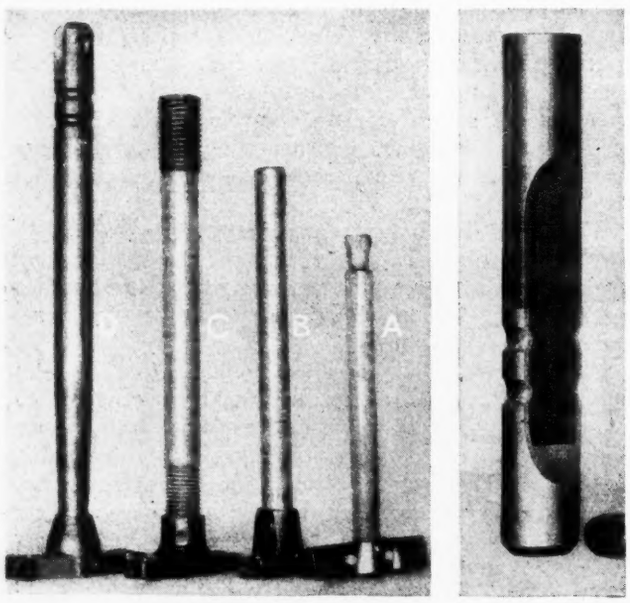


Fig. 1—Left: Methods of attaching the moving contacts and lever system to the lift rods. Right: Cross-section through fitting rolled on end of a lift rod D

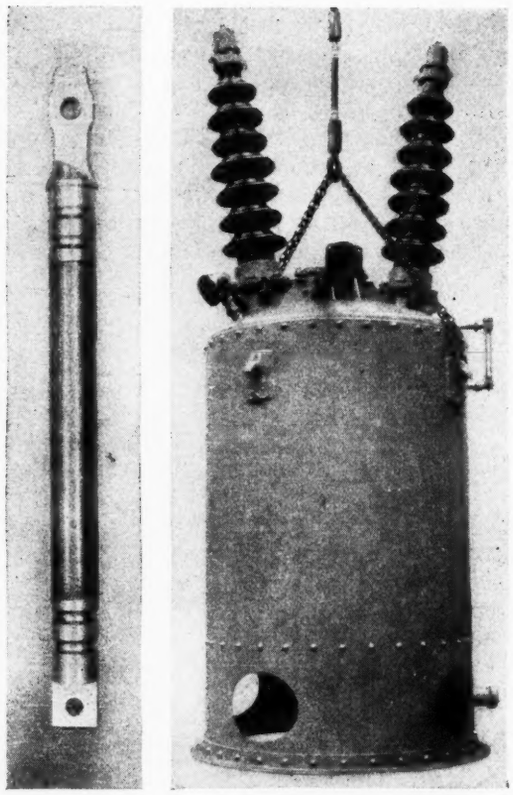


Fig. 2—Left: Laminated-wood lift rod. Right: Oil switch being lifted by a laminated-wood rod

Maple, hickory, and ash have been used with varying success. Maple is the strongest and the best insulator, but straight grained lumber is becoming more and more difficult to obtain. Quarter sawing, even the resorting to split billets, together with the closest of inspection does not eliminate cross-grained material. The strength of hickory varies greatly, and there is a tendency toward sappy streaks, which reduce the insulating value. Ash has a tendency to break off short when subjected to impact stresses such as are imposed on the lift rod in circuit breaker operation.

With the increasing speed of operation of circuit breakers and the development of heavier contacts for larger circuit breakers the problem becomes much more acute. Doubling the size of the stick does not double the strength, while the probability of defects is more than double.

A synthetic material the manufacturing processes of which can be rigidly controlled is desirable. Such a material, known as wood-base Micarta, has recently been developed. Veneer stock, as used in making ply wood, is saturated with phenolithic resin, then built up and pressed into a board of suitable thickness and length. While in the press, heat is applied to cure the binder. The result is a dense material that is uniform in strength and with no cross-grain tendency. It is

superior to treated wood as an insulator, because all air has been eliminated in the processing.

Veneer stock is used rather than paper because the fibers in the veneer stock all lie parallel to the direction in which maximum strength is desired. Further, the breakage of the fibers by pulping and callandering is eliminated. A veneer stock that is decidedly porous, with fuzzy fibers, is used. In the building process the space between the fibers is entirely filled with the binder. The entire mass reduced in bulk by pressure, so that the resulting product approximates hard wood in appearance.

This product has a breaking strength of the weakest specimen well above the breaking strength of the best natural material. The problem of inspection practically disappears because of the uniformity of the product as manufactured. Fig. 2 (left) shows a lift rod made of this material for a 2,000-amp. 15,000-volt circuit breaker where the contact element weighs 70 lb. Fig. 2 (right) shows this same rod being used to lift one unit of a 110,000-volt circuit breaker.

The ends of the lift rods can be shaped in various ways to attach to the moving contact or lever system, the choice depending on the service. Fig. 1 (left) indicates some of the various methods used on different applications. At *A* is a rod with a simple wedge-shaped end, is gripped by the moving mechanism. This is satisfactory where the speed of operation is low and the contacts light in weight. At *B* the fitting is driven on the rod and the strain taken by tranverse rivets. This construction is considerably stronger than the first and is satisfactory for light-weight contacts with comparatively high-speed operation. The third rod *C* is threaded to provide adjustment and greater strength than the second. This is satisfactory for slow-moving, heavy contacts. For heavy contacts and high-speed, with resulting high impacts, the construction equivalent of *D* is preferred. At the lower end a malleable-iron casting is shown that has been swedged around a knob left on the end of the stick. The fitting at the upper end has been rolled on to the stick, which has been grooved at the points of rolling. The construction shown at the upper end is the strongest method of attachment.

Causes of Elevator Wire-Rope Failures

By C. B. Garrison
Chief Engineer, Union Central Life Buildings

THERE has been much discussion recently on the subject of wire rope. It has been my experience that wire rope seldom wears out by external abrasion from contact with the sheaves or drums. It is usually removed when a number of wires or strands fail by fracture. I have found that wire-rope failures can usually be attributed to one or more of the following causes:

1. Material too hard.
2. Unequal tension put in the strands when the rope is made.
3. Lack of flexibility, due to wrong construction.
4. Fatigue of the wires.
5. Lack of core lubrication.
6. Internal abrasion because of the wires being too soft.

A crucible cast-steel 6x19x$\frac{5}{8}$ rope might be too hard and not give as good results as an 8x19, or similar construction, of mild steel. When making elevator rope equal tension is not always maintained in the wires and strands during the laying process. To obtain data on this condition, I took a piece of 6x19x$\frac{5}{8}$ iron rope 24 in. long and subjected each strand to 1,000 lb. tensile load. While under tension the length of each strand was measured. A variation of $\frac{3}{16}$ in. in the length of the strands was obtained. This change is equal to 37$\frac{1}{2}$ in. in a 400-ft. rope, such as is used in the Union Central Life Building, Cincinnati, Ohio. It is evident that such a condition might cause the strands to fail while in service.

Continual vibration at the ends of long elevator ropes has fatigued the wires to such an extent that they become crystallized and fail near the shackles.

Internal lubrication is necessary to prevent corrosion and reduce internal abrasion. Reels of rope have been purchased that contain practically no core lubrication.

The bending movement of ropes running over sheaves or drums is a primary cause of elevator-rope fractures. Calculations made on a 34-in. sheave with grooves $\frac{9}{16}$ in. wide and $\frac{1}{4}$ in. deep, gave the circumference at the bottom of the groove, or that part which comes in contact with the rope, as 50.658 in. The outer circumference of a $\frac{5}{8}$-in. rope in this groove is 52.121 in., a difference of 1.463 in. Therefore, for the rope to conform to these different circumferences it is necessary to change the lay, or the top of the rope will elongate, the excessive strain usually resulting in fractured wires.

The following is an extract from a letter sent out from the engineering department of a well-known rope manufacturer, in reference to an inquiry on this question.

"In this regard it is, of course, essential that there be some means of compensation for the greater travel of the outside circumference of the rope, in relation to the lesser circumference of the inside portion of the rope in contact with the bottom of the sheave groove.

"The construction and fabrication of the rope itself is the primary compensating feature. To a small extent, this is taken up by compression on the inside; but by far the major part is due to elasticity or elongation of the outer circumference.

"While flexibility and elasticity of fabrication help to overcome this feature, at the same time it is also necessary that the metal of which the rope is made be subject to some degree to these stresses, which are directly accountable for crystalization. For this reason, the correct rope type must be arrived at in order to reduce crystalization stress to a minimum.

"We therefore arrive at the fact that bending stress is the greatest detriment to wire-rope life, with abrasive wear and load factor next in importance, in the order named. It is, of course, to some extent subject to control. This is done by larger drum and sheave diameters, by which, in the use of a given size rope, the ratio of rope travel between outside and inside circumference is reduced.

"While the figures for modulus of elasticity of wire rope are rather indefinite, and vary with the individual, it is an agreed fact that the figures decrease directly as the flexibility of rope construction increases."

To determine whether wires fracture in a rope subjected to excessive tensile load, numerous wires from the same section of a rope were tested at the University of Cincinnati. It was found that wires that were subject to fracture were of the same tensile strength as those that were free from fractures. It was also determined, when breaking a $\frac{5}{8}$-in. rope, that usually one strand will fail first, which is evidence that the wires and strands were unequally stressed, causing one or more to carry the entire load.

Right Out of the Plant

Holding Sheet Rubber While Cutting

THE common pocket knife is not the best tool with which to cut soft sheet rubber, but it is usually the only tool handy when work of this kind has to be done. Spread the two-foot rule slightly and cut between the

Rule prevents packing drawing up when being cut

halves as shown, pressing the parts of the rule firmly to the sheet with the fingers. This simple expedient keeps the rubber from drawing up as the knife goes through it, and allows a clean straight cut along the mark.

Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

The Refrigerating Engineer Needs Technical Knowledge

DURING the last decade the improvements accomplished in the economical generation and utilization of power have been so great that we marvel at their extent and scope when we compare present conditions to those which prevailed not so long ago. This state of affairs may be directly traceable to the fact that power engineering has been given a mighty impetus by the vast army of engineering students that our universities have been turning out.

It is not beyond reason to say that the greater number of our radical and decided improvements have germinated in the brains of these youngsters, although the credit may have finally settled on their chiefs.

One great engineering executive, in charge of power generation, has remarked that his greatest concern regarding the education of his son is that his boy be fortunate enough to gain a true perspective of the fundamentals of engineering. A proper understanding of the fundamentals he regards as of more importance than the most extended and intensive specialization, for a poor comprehension of the fundamentals will always remain a stumbling block to future development.

A thorough knowledge of the fundamentals of power engineering is not so easily gained as many would be inclined to aver. The mere fact that one is dealing with a fundamental seems to induce the opinion that the matter is relatively simple, which is seldom the case. The most difficult and involved problems must, in many cases, be mastered before a fundamental may be viewed in a true light. One has only to follow through the proceedings and discussions of some of the engineering societies to see evidence that many, thinking they have a thorough grasp of the fundamentals, have only a confused idea.

The generation of power has been improved so much that one wonders what the next step will be; but there is one branch in power engineering that has not gone ahead at the pace it should. That branch is refrigeration. It is notable that refrigeration was born in the hands of a professor in a university, but its high birth has not influenced its fortunes through life. Today we find refrigeration in a state that can hardly be classed with that of power generation, because people will not bring themselves to master the fundamentals.

We read of power stations having all sorts of instruments to measure CO_2, excess air, steam flow, water flow and condensate. In fact the engineer knows to the split of a hair the B.t.u. that come into the plant in the coal or oil, and he knows to a three-point decimal the B.t.u. that go out on the transmission lines. If a factory needs a great amount of process steam our modern engineering student is not fool enough to let it be taken directly from the boiler. His knowledge tells him that method is wasteful. Power is first gotten out of that steam before it is turned over for process work. If the demand for process steam fluctuates, an accumulator is installed and the boilers go on making steam at a predetermined, steady, economical rate, instead of "jumping all over the shop" like the demand for process steam.

Have any improvements like these been applied to refrigeration? Not so you could notice it. When an engineer wants a thermometer on the suction or discharge of his compressor, he is told that the thermometer will not make the machine freeze any better. Compressors are installed with clearance pockets for adjusting capacity, and the higher-ups tell the engineer not to use them. Venturi meters for measuring liquid ammonia and brine flow are laughed at as useless appendages. And these same men that consider measuring instruments to be trinkets will set about and install an ice cream plant with a cooling tower and with no fan and then try to pump ammonia vapor from a pressure of two or three inches of vacuum in the ice cream harding room up coils to 230 lb. head pressure in the condenser in a single compression. The lubricating oil is turned into ebony and coated all over the discharge valves. The ammonia is cracked and the condensers filled with hydrogen and methane. And these same men consider themselves refrigerating engineers.

The common retort one generally receives when he suggests making this wide compression in two jumps instead of one, thus splitting the big ratio, is, "Why pay for two cylinders to do the work in when it can be done in one cylinder?" The inane philosophy of this makes a hit with some people, but the downright crass ignorance

of the remark is obvious. To many engineers, heat of compression seems to be a fixed factor. Its connection with power consumption is only vaguely suspected. They seem to half recognize that some of the heat of compression may be eliminated in an intercooler between the stages, but they always keep sight of the fact that the extra cylinder and intercooler are extra equipment that they have to pay for. They never glimpse the fact that the economy of the extra cylinder and the intercooler is something that operates every hour the plant is running and will soon pay for itself, while the saving in first cost by not buying them is soon swamped by a power bill in excess of what it should be.

Clearance pockets are called power wasters; compound compression is a nuisance; and multiple effect is branded as a fool idea.

It seems funny that some people can take these same devices that are categorically described as rubbish and produce some unequaled results with this same rubbish. Whom are we to believe? If we were all equipped with the necessary fundamental knowledge of refrigeration that we should be equipped with, our judgment would never falter. There would be only one irrefutable course.

The charlatan would have no chance. The United States government has constructed a large Mollier chart for ammonia, using the common American engineering heat units. The chart is sold for a trifling sum, as is also a book of tables of the properties of ammonia. With these the average American refrigerating machine operator after a little careful study can work out numerous problems that concern the efficient operation of a plant. But it is quite safe to say that not three in a hundred operators can even pick out the path on the chart along which their machine is compressing.

Why should this state of affairs obtain? For the simple reason that there is a little work entailed to become proficient in the use of the chart, and that work is the stumbling block. The average operator wants to gain knowledge like he would take medicine. That cannot be done with engineering fundamentals. Some think it can and reckon themselves smart fellows. The Mollier chart clears up a lot of mysteries to those who study its make-up and use, but it is simply a piece of wallpaper to most engineers.

Refrigeration is now coming into more general use, but while its progress may be inevitable, this same progress may be retarded by ignorance and prejudices, or it may be hastened by ingenuity and knowledge.

New York City. F. P. MacNeil.

What Causes Air-Receiver Explosions?

REGARDING the letter of C. O. Sandstrom in the Sept. 10 number on "What Causes Air-Receiver Explosions?" the theory he advances seems to be well borne out in practice.

Fires and explosions in some types of air compressors are numerous, and dangerous. In the past few years I have investigated over 50 explosions occurring in a type of three-stage air compressor used for fuel injection, but now considered obsolete. However, the operation of this type of compressor serves to bring out the points mentioned in Mr. Sandstrom's letter, namely: Excess lubrication and sulphur gases do cause explosions. I do not agree, however, that leaky valves can be neglected as a cause of explosions under some conditions.

The explosions investigated occurred in compressors operating at altitudes varying from sea level to 8,500 ft. above, and occurred in the receivers, intercoolers and aftercoolers; some being violent, others merely fires. The fires generally occurred when excess lubrication only was in evidence; the explosions, particularly the most violent ones, when both excess lubrication and sulphur gas were present.

The excess lubrication was due mostly to the design of the compressor allowing a quantity of oil to be pumped from the crankcase. Also, a large quantity of oil vapor was drawn into the low-pressure stage, due to the air in the engine room being saturated with lubricating-oil vapor from the engine crankcase. The sulphur gases came from the leakage past the pistons of the power cylinders.

In the majority of the most violent explosions there was present a large quantity of partially burned lubricating oil, on valves, valve chambers, and in the receiver. Fig. 1 shows the deposit on a low-pressure and a high-pressure valve after only a few days' operation. In this case the suction pipe was in the zone of the hot oil-vapor

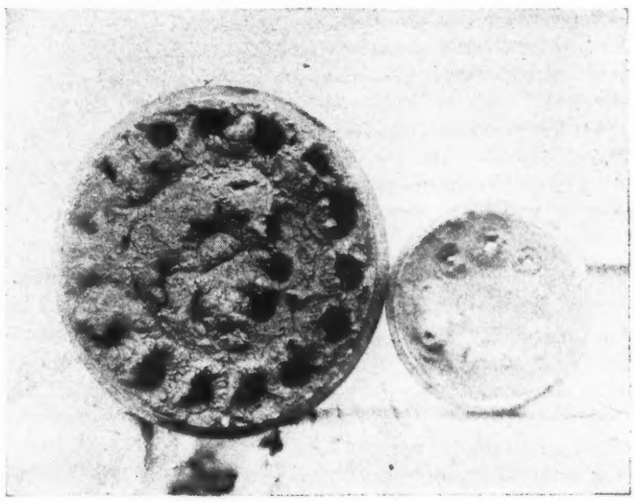


Fig. 1—Condition of low- and high-pressure valves after a few days' operation

discharge from the engine crankcase, as well as the hot sulphur-charged exhaust gases from the power cylinders. Fig. 2 shows the violence of an explosion in an air receiver and an intercooler.

Consider this typical case, where fires and explosions are accepted as general routine: The normal discharge pressure of the low-pressure stage was 65 lb. This under ordinary conditions is safe enough, but under the conditions previously mentioned is dangerous, if for no other reason than that the inlet air is highly charged with vapor and highly preheated. When the valves and valve chamber became fouled the indicator showed that, while the pressure in the receiver was 65 lb., the pressure inside the cylinder was about 110 lb. This pressure in single-stage compression would be dangerous enough under ordinary conditions, but under the conditions mentioned it practically meant a fire or an explosion. Where excess lubrication only was in evidence, a fire was generally the result, explosions sometimes being great enough to blow the safety valves to pieces, but not enough to wreck the receiver.

The ignition temperature can be reached, in a three-stage compressor, if either the low-pressure or the intermediate-pressure drains are carelessly operated. In this instance the stage pressures were: low pressure, 65 lb.; intermediate pressure, 365 lb.; and high-pressure

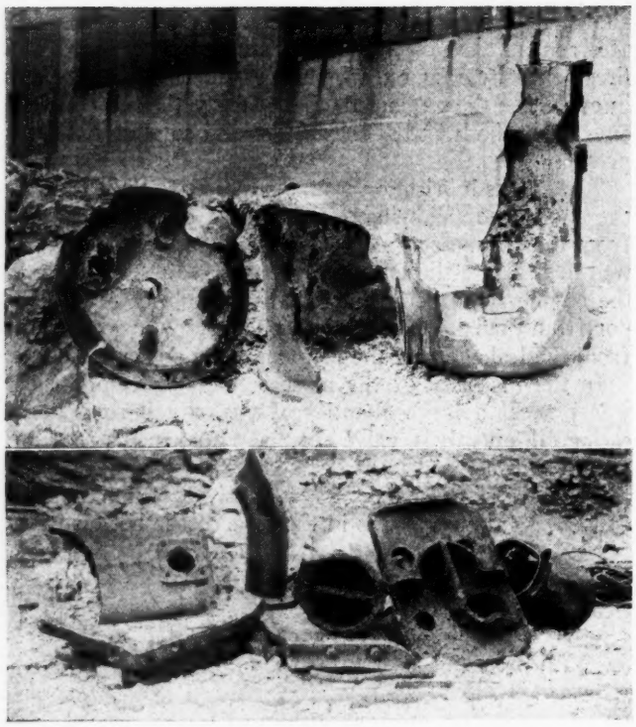


Fig. 2—Explosion of air receiver and high-pressure intercooler

1,300 lb. gage. If the low-pressure drain is suddenly opened wide the pressure will drop to about 25 lb. This will increase the ratio of compression at this altitude from the safe figure of about 5 to the dangerous one of about 9, in the intermediate-pressure stage; similarly for the high-pressure stage when the intermediate-pressure drain is carelessly operated.

Throttling of the suction on the low-pressure stage or in a single-stage compressor can easily cause high temperature, if the discharge pressure remains constant, and in many cases even when the discharge pressure is considerably reduced; for after throttling much below atmospheric pressure the ratio of compression increases rapidly.

Numerous explosions were caused by defective valves, lack of proper lift and opening causing greatly reduced suction pressure and a highly increased discharge pressure, resulting in an increase of the compression ratio. The intercooler and aftercooler explosions were due to some part being eaten away by acid, allowing the high-pressure air to enter the water jackets, blowing them up. The lower view in Fig. 2 shows the effects of an explosion of a high-pressure intercooler jacket. These explosions are always violent and dangerous, especially when no safety plates are provided.

Globe, Ariz. J. J. McDougall,
Maintenance Engineer
Arizona Edison Company

Why Flanged Pipe Joints Leak

UPON reading the article by Arthur McCutchan, "Why Flanged Pipe Joints Leak," in the Sept. 10 number of *Power*, I could not help noticing that he entirely omits one of the most important factors of all, and that is the gasket. He writes at considerable length about the flexibility of the bolts used in the joints, but nothing is said about the flexibility of the joint gasket.

It was pointed out by a prominent national committee a few years ago that important advantages are to be gained by making joints flexible, whereas Mr. McCutchan apparently thinks that joints should be made stiff.

It is my opinion that if Mr. McCutchan would use a first-class thick flexible metallic gasket in his flange pipe joints he would find that most joint troubles would vanish. The idea seems to prevail that to prevent leakage a gasket must have as little thickness as possible and must be squeezed so thin that the distance between the faces of the flanges is negligible. In fact, attempts are made to do away with the gasket entirely by grinding the joint faces and making an almost perfect fit. Under some conditions this gasketless method "works," but where circumstances are not so favorable, as described by Mr. McCutchan, trouble is sure to result because of the very stiffness of the joint. Flexibility is necessary.

Very often when applying gaskets we see the engineer or pipe fitter slip a pipe over the wrench handle, thereby increasing the wrench's leverage and making it possible to increase considerably the pressure of the flanges against the gasket. As a result the gasket is squashed. If it is made of corrugated metallic material it is flattened to a point where the corrugations can do no good whatever.

The most important objection to the very thin gasket is that no matter how it is constructed it can have but little expanding or contracting capacity, consequently all expansion and contraction must be taken care of in some other manner. Mr. McCutchan proves mathematically that bolts cannot be relied upon to take care of expansion and contraction. The logical solution therefore would seem to be the use of thick flexible gaskets.

Newark, N. J. W. F. Schaphorst.

Practical Stud Extractor

WITH reference to the stud extractor described by F. P. MacNeil in the Aug. 6 number of *Power*, I have developed and patented a practical and handy tool, along the lines of a wrench, especially for this purpose.

Referring to the illustration, the tool is simply a handle with an enlarged end having an opening to fit over the stud and a free-moving toothed jaw, as shown. When

Stud extractor designed along the lines of a wrench

the tool is placed over the stud and pulled in the direction to unscrew it, the jaw automatically grips the stud. Turning in the opposite drection loosens it. The standard tool is, of course, about 2 ft. in length.

Los Angeles, Calif. R. H. Fulton.

What's New in Plant Equipment

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING TRANSMITTING AND APPLYING THE POWER SERVICES

High Tensile Strength Welding Rod

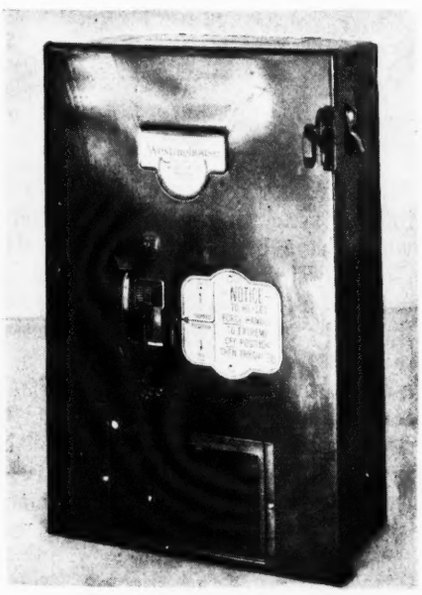
FOR flat, vertical and overhead manual welding and flat automatic welding, a high tensile welding rod, "Una" No. 65, has been developed by the Una Welding & Bonding Company, Cleveland, Ohio. It is available in unit packages of 25 lb. in standard sizes, varying from $\frac{1}{8}$ to $\frac{1}{4}$ in. in diameter and 14 in. in length, and also in rolls for automatic arc welding.

The rod is particularly suitable for the welding of boilers, tanks, cast-steel and structural shapes requiring high tensile strength, and may also be used for building up wearing surfaces that require machining.

The rod, which is claimed to have a tensile strength of 60,000 lb., is coated and is designed to permit stripping at any point and establishing an arc instantly.

Meter Service Breaker Replaces Fuses

A POSITIVE automatic circuit breaker for use on meter services in place of fuses is announced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. It is designed to withstand temporary overloads, but to open the line before any damage can be done to the equipment or to the insulation of the conductors.

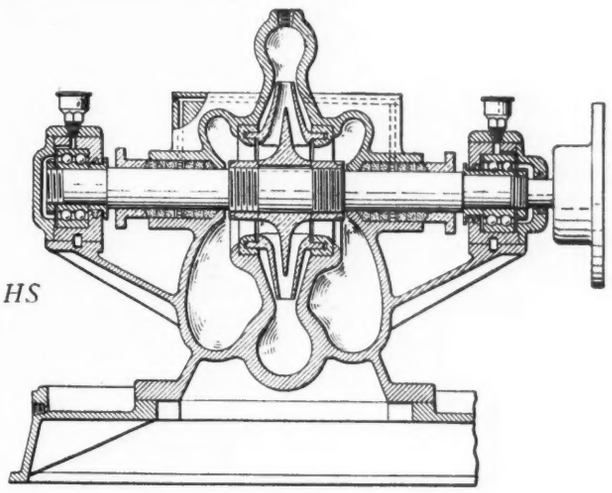


Circuit breaker for two-wire solid-neutral service

The breaker is operated by a quick-make, quick-break toggle switch. It is controlled from the front by an improved insulated handle, which can be locked or sealed in the "off" position if desired. The box is of the usual form and dimensions, with arrangements made for ordinary meter trims and banking troughs.

Since there is no need to have access to the circuit breaker mechanism, it is sealed inside an insulating cover. External connections make it unnecessary to disturb the circuit breaker and facilitate wiring.

The self-heating bi-metal operating the latch on the breaker will not fuse on any overload current that can be obtained at the rated voltage. In case of mechanical failure this U-shaped bi-metal acts in the circuit as a link fuse and opens the circuit. The breaker is for 30-amp., 125-volt, 2-wire, solid-neutral service.

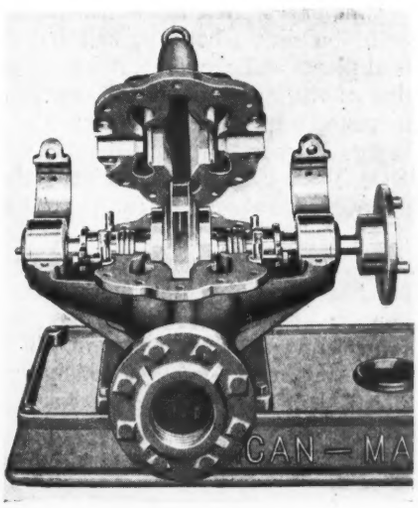


Cross section of type HS high-head pump

Ball-Bearing Pumps for General Industrial Services

BALL - BEARING centrifugal pumps for general service in both low-and high-head types have been added to the line of pumps put out by the American Steam Pump Company, Battle Creek, Mich. The new units are suitable for practically all kinds of industrial service, including hot and cold water circulating, pressure boosting, boiler feeding and similar uses.

Both the low- and high-head units are of the double-suction type, with the casing split horizontally at the center line. The bearing supports and suction and discharge connections are cast integral with the lower half of the casing.



Type HL low-head pump

The impeller is of the inclosed type, with a non-overloading characteristic. The shaft furnished on the low-head pump is of open-hearth steel, protected on each side of the impeller and through the stuffing boxes by removable bronze sleeves. The shaft furnished on the high-head pump is of stainless steel, and no protecting

sleeves are used. The shafts are carried in oversize self-aligning ball bearings designed to take care of thrust and radial loads. The stuffing boxes are made deep enough to accommodate six rings of packing and a water seal. The bronze glands are split and are of the bolted type. A flexible composition disk-type coupling is furnished for direct motor or steam turbine drive. For belt drive, a cast-iron crown-faced pulley is mounted on the shaft between two bearings, the unit in this case having three bearings.

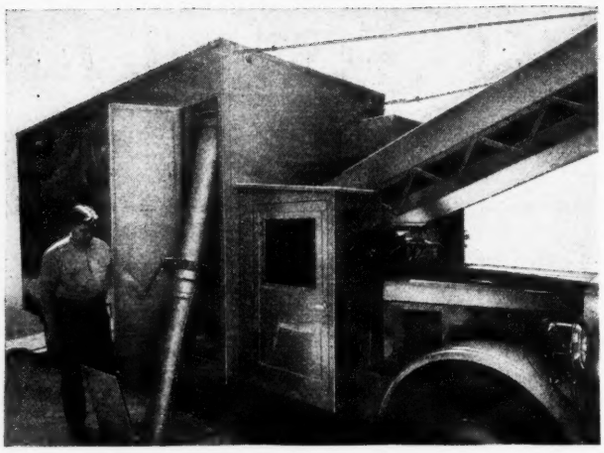
The low-head pump, which is designated type HL, is available in sizes from $1\frac{1}{2}$ to 6 in., with capacities ranging from 90 g.p.m. at 40-ft. head to 1,200 g.p.m. at 82-ft. head. The high-head pump, designated type HS, is available in sizes from $1\frac{1}{2}$ to 4 in., with capacities ranging from 100 g.p.m. at 175-ft. head to 600 g.p.m. at 230-ft. head. Pumps are also available with the casing built of a non-corrosive or acid-resisting alloy.

Portable Electric Pneumatic Ash-Handling System

WITH a view to providing a more practical means of removing the ashes from the basements of office buildings, hotels, small industrial plants and similar buildings than that of the conventional ash can now in general use, the Pneumatic Conveyors Corporation, 522 Fifth Ave., New York City, has introduced the electric - pneumatic suction system illustrated.

The equipment comprises an ash-handling truck containing a large hopper, into which the ashes are drawn by suction and from which they are conveyed by a totally inclosed belt conveyor to a carrier-truck.

The ash-handling truck is equipped with the gas-electric drive now in extensive use for heavier vehicles. Power for operating the suction system and the conveyor-belt is obtained by connecting the electric generator to the motor and running the engine of the truck at the necessary speed.



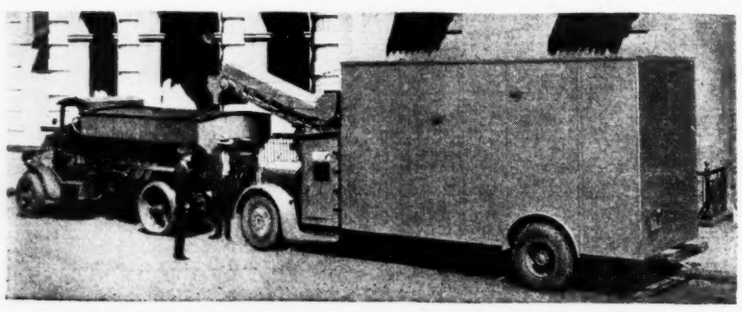
How suction connection is made at the street level

Suction is provided by a centrifugal compressor, rated at 6,000 cu.ft. per minute at a speed of 3,500 r.p.m. and driven by a 40-hp. motor. The truck has a piping capacity that permits a suction of 2,800 cu.ft. per minute, equivalent to a velocity of 145 ft. per second in the intake pipe. This gives the outfit a capacity per minute equivalent to the contents of a dozen standard ash cans.

The truck connects to the pipe line from the ash pit at the sidewalk opening by a pipe section attached to the truck and connecting to the hopper. This pipe section is lowered into place and tightly connected with the permanent pipe line, so that no dust escapes to the outside air at any point.

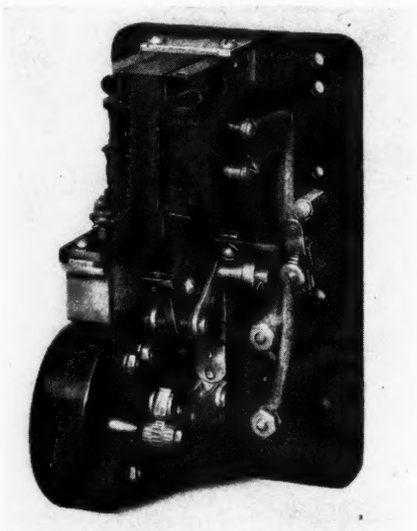
The unit illustrated was built for the Pneumatic Conveyors Corporation by the American Car & Foundry Motors Company, and was electrically equipped by the General Electric Company.

Gas-electric truck with self-contained ash hopper, motor-driven suction system and totally inclosed conveyor



Redesigned Motor Starters Have New Meters and Relays

THE new rectangular type of meter with non-glare glass (see *Power*, June 25) and a new type of



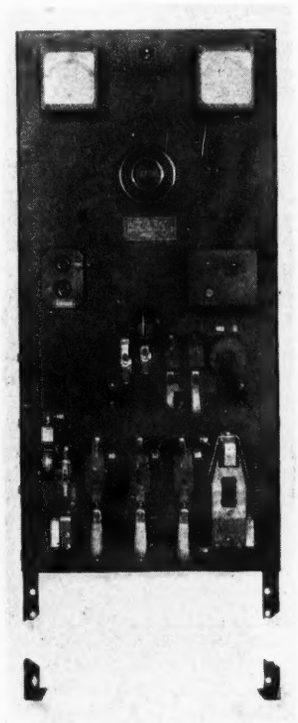
New field-actuating relay

field-actuating relay are incorporated in the synchronous motor starters which have been redesigned by the General Electric Company, Schenectady, N. Y. CR-1135 is the designation of a line of semi-magnetic, reduced-voltage starters for synchronous motors, designation CR-7061 covers magnetic reduced - voltage starters, and designation CR-7065 is assigned to a line of magnetic full-voltage starters for synchronous motors, all having been revised to incorporate the new devices.

The operation of the new field-actuating relay, which controls the field contactor, is dependent upon the

speed of the motor and, in addition, a definite time delay after the motor reaches approximately 95 per cent speed. When full voltage is applied to the motor the immediate closing of the relay contacts is prevented by a lock-out coil in parallel with the discharge resistor and energized by the voltage across this resistor.

The lock-out coil holds the relay contact arm motionless until the motor accelerates to approximately 95 per cent of synchronous speed, when the voltage across the resistor decreases and allows the lock-out coil to release the timing mechanism. After a predetermined time the relay contacts close, energizing the field contactor and applying field to the synchronous motor. The closing of the relay contacts may be delayed for several seconds after the lock-out coil releases the timing mechanism.



Control panel with rectangular type instruments and new field relay

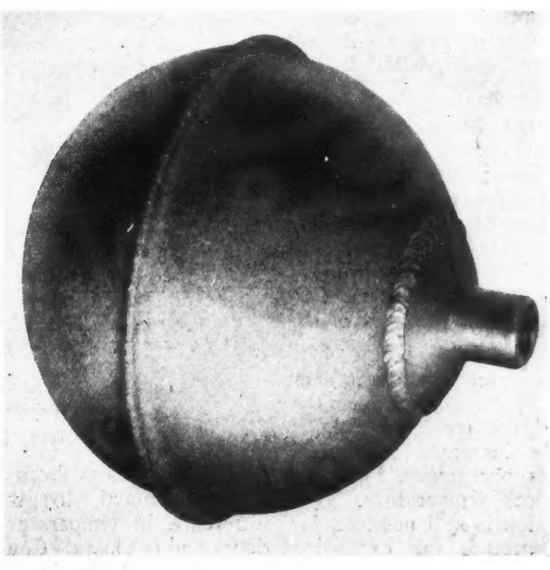
In operation, throwing the handle of the compensator on the CR-1135 controller connects the motor to the line through the low-voltage taps of the compensator. When the handle is in the "run" position the motor is connected directly to full-line voltage. The field-actuating relay is energized at the time the handle is moved to the "run" position, and when the motor has reached approximately synchronous speed. This relay operates and energizes the field contactor, which applies excitation to the motor field. Pressing the "stop" button drops out the compensator switch and disconnects the motor from the line.

Pushing the "start" button energizes an accelerating contactor which connects an auto-transformer to the line and the motor to the taps of the auto-transformer. Simultaneously, a definite-time relay is energized. After a time interval corresponding to the setting of the definite-time relay, the acclerating contactor opens, disconnecting the auto-transformer from the line and the motor, and the line contactor closes, connecting the motor directly to the line. When the motor reaches approximately synchronous speed, the contacts of the field-actuating relay are closed and the field contactor closes, applying field to the synchronous motor. This completes the starting operation.

Welded Steel Float for Steam Pressures Up to 1,500 Pounds

ALTHOUGH developed primarily for use with the Nicholson piston- and weight-operated steam traps, the line of welded steel floats, for all steam pressures up to 1,500 lb. and hydrostatic pressures up to 2,500 lb., put out by W. H. Nicholson & Company, 12 Oregon St., Wilkes-Barre, Pa., is now available for all types of equipment requiring the use of high-pressure floats.

The floats are made of a special alloy steel, with the two halves welded together and the spud welded on the outside surface. They are afterward heat-treated, polished and nickel-plated to prevent corrosion. The floats are available in any size from 3 to 10 in., either round or elliptical shape, suitable for use in steam traps, water columns, tanks, level controls and similar equipment. Floats can also be furnished with specially shaped spuds, or with the spud welded on the seam or at any point on the surface with relation to the seam. Floats pressed from monel metal, Ascoloy, Duraloy and other brands of stainless steel for pressures up to 300 lb. hydrostatic can also be furnished.



Welded steel float with spud welded on the outside

High-Strength Bronze Welding Rod

HIGH strength, with low melting point is claimed for the Oxweld No. 21 welding rod put out by the Oxweld Acetylene Company, a division of the Union Carbide & Carbon Corporation, 30 East 42nd St., New York City.

The rod may be used for the bronze welding of steel, bronze, brass, cast iron, malleable iron, wrought iron, copper, nickel, monel and similar metals. The new rod can also be used for building up wearing surfaces and for fusion welding of bronze, brass and other copper alloys. The manufacturer claims for this rod a metal which gives a weld equal to, and in many cases superior to, the original metal from the standpoint of soundness, strength and ductility. It is also claimed to have a composition which does away to a large extent with the fumes given off in welding operations.

FROM AMONG READERS' PROBLEMS

Conducted by L. H. MORRISON

SULPHUR IN FUEL OIL—*Is it true that sulphur in fuel oil will eat the exhaust line of a Diesel engine. We have a 120-hp. semi-Diesel with an exhaust line that runs 200 ft. horizontally and then vertically 40 ft. The horizontal pipe is cast iron, and it has corroded entirely through the wall.* J. J. B.

Ordinarily the sulphur in the fuel oil will not harm the exhaust line, for after fuel has been shut off, the engine turns over a few times and the air discharged into the exhaust line will clear it of any water vapor and sulphur fumes that might unite to form sulphuric acid. In your case, however, the exhaust is entirely too long, and it cannot be cleared of the fumes, which, when the pipe cools, condense. The resulting acid will rot the pipe. You should make the pipe as direct and as short as possible.

NUTS BURN ON EXHAUST CONNECTIONS—*We have a number of semi-Diesel engines having handholes in the exhaust elbows to permit the removal of carbon from the exhaust ports. The nuts burn and cannot be removed readily. Can this be avoided?* A. C. R.

If you obtain monel metal nuts you will find that these will not burn to the studs, and can be removed easily.

PERCENTAGE OF WATER WALLS—*What is meant by the expression "fraction cold," when applied to furnace walls?* J. E. C.

"Fraction cold" is often used when the relative areas of the furnace walls that are provided with water walls and with refractory lining are under discussion. If half of the area is water-cooled, the "fraction cold" is one-half.

CARBON-DIOXIDE REFRIGERATION IN WARM CLIMATES—*It is my understanding that the critical temperature for CO_2 is approximately 86 deg. F., and that if the cooling water is above this temperature the CO_2 gas will not condense regardless of the pressure. If this be true, how can you use a CO_2 system in the Southern states or in the tropics?* G. F. C.

If the condenser temperature is over 86 deg. F. the CO_2 gas coming from the compressor will not condense even if the pressure be increased to several thousand pounds per square inch, for this is the "critical" temperature.

But refrigeration is still possible, for in expanding through the expansion cock some of the condenser gas liquifies at the lower evaporator-coil pressure, and this re-evaporates and absorbs heat through the coil wall.

For example, suppose that the amount of cooling water was such that the CO_2 gas could be cooled to 95 deg. F. while the condenser pressure stood at 1,200 lb. per square inch C. In this condition the CO_2 would be a gas containing 60 B.t.u. per pound as measured from 32 deg. F. The gas would have a density greater than it would possess as a liquid.

If the expansion valve is opened, the 1,200 lb. gas will flow into the coils, which we will assume to be at 300 lb. pressure, and the fluid will have the same total heat as before, namely, 60 B.t.u. per pound. When, in the passage through the valve, a pressure of 950 lb. is reached, a temperature-heat chart of CO_2 reveals that the pound of CO_2 must contain 80 B.t.u. to be in a vapor state, of which 35 B.t.u. is the heat of the liquid and 45 B.t.u. the total heat of vaporization. Consequently, the fluid becomes partly a liquid and partly a saturated vapor, the proportions being, approximately, 50 per cent of each. When 300 lb. is reached, about 60 per cent is vapor and 40 per cent is liquid. To evaporate into vapor at this temperature and pressure, the liquid must absorb 120 B.t.u. per pound, so the 0.4 lb. will absorb 48 B.t.u.

It is obvious that while warm condenser water reduces the refrigeration per pound it does not entirely destroy the action.

NET PRESSURE ON A PISTON—*Is the net pressure on a piston forcing it to move on its stroke, the steam pressure minus the back pressure at that point as shown on an indicator diagram?* S. W.

The steam engine indicator makes a diagram of the events in one end of the cylinder. The pressure line is made during the power stroke, while the back-pressure line is made during the return stroke. The difference between these two lines does not give the net forward pressure at any given instant. It is necessary to find the difference between the steam pressure in the head end and the back pressure in the crank end of the cylinder.

SAND BLASTING CONDENSER TUBES—*Our condensing water is taken from a river and comes with considerable silt in suspension. This silt settles along the tubes and forms a thin hard scale. Sand blasting of the tubes has been suggested. Is this advisable.* R. A. A.

There is no doubt that sand blasting will remove any thin scale, but the disadvantages will outweigh the advantages. The sand will cut the polished brass surface into grooves and the roughened tube will probably increase the frictional resistance sufficiently to offset the minute increase in the vacuum obtained.

PREVIOUS QUESTION

DISCUSSED BY READERS

THE QUESTION

TO WHAT extent is it economical to allow the temperature of an office building to drop during a winter night? R. P. B.

THE heat loss from a structure is proportional to the maintained difference in temperature between indoors and outdoors. Consequently, during periods outside of regular occupancy, it is economical to drop the indoor temperature as low as the safety of the plumbing permits.

Sufficient excess radiator surface must be provided for a quick rise in temperature before the next period of occupancy.

In addition, there must be such control that overheating will not result from the excess radiator surface.

If the operation of a heating plant is regarded as the performance of a device to transport heat, and it is further understood that in this heat-transporting operation the heating plant is as definitely limited by conditions entirely outside its function as the automobile is limited, the entire heating situation will be much better understood.

No one yet knows how much air any structure leaks. Laboratory data avail-

able from tests of component parts, such as sash and frames, while valuable in themselves, are of as little use in the final conclusion as a food analysis is to determine what the cook does to the food in the kitchen.

Another item too little understood is the necessity for exact control of building-atmosphere pressures, as well as for the control of air flow through the building.

More general use of condensation meters, with competent analyses of the records from the meters, would do more to promote a better understanding of the real relation of cause to effect, in heating, than any other single factor.

There is an enormous fund of knowledge concerning heating, but what is known so far is but a small part of what is yet to be learned. Heating and ventilating engineering is considerably less than 100 years old. It is in a greater ferment now than is any other field of human effort. When this ferment subsides we will recognize present accepted heating practice as lacking a sound basis of principles.

Notwithstanding, heating engineers have already contributed as much to our standards of modern comfort as any other branch of engineering. They are still going strong.

J. M. Robb,
Peoria, Ill. *Heating Engineer.*

IT IS impossible to set a definite limit as the economical point to which the temperature of office buildings should be permitted to drop during the winter night hours.. In some buildings it would probably be unwise to permit the temperature to drop more than a few degrees, while in others a drop of as much as ten degrees might result in a fuel saving. The economical point is, obviously, that which will result in a definite saving in fuel.

Since every building will vary as to the ease of heating, the ratio of installed radiation to boiler capacity provided, and the efficiency of the boilers at various loads, each building represents a different problem. The solution of the problem offers no great difficulty, since a variation in practice results in an increased or decreased fuel consumption, and the results obtained will dictate the proper method.

In general, it is reasonable to expect that a drop from the normal day temperature should show a fuel saving. This is true when it is possible to again raise the temperature in the early morning hours without forcing the boilers beyond their economical rating. However, the loss in efficiency of the heating plant under forced ratings may in many cases be more than sufficient to overbalance any savings effected during the night hours.

The problem thus becomes one for the building chief engineer to solve. The results of his observations and tests should dictate the lowest economical temperature that should be maintained during the non-working hours.

K. E. DeRosay,
The Atlantic Refining Co.
Philadelphia, Pa.

IT depends on the type of heating service required. We had 18,000 sq.ft. of radiation supplied a five-story section of a telephone building, the fourth and fifth floors being operating and testing rooms with 24-hr. service.

The building was extended to seven floors; the added two floors are office space that require 10-hr. heating service, an additional 5,000 sq.ft. of radiation. On the fifth floor, gate valves were fitted on the up-feed steam risers, which were at first shut off at 6 a.m. The temperature drop varied on the sixth and seventh floors, depending on the outside atmosphere conditions. It was found in actual practice that the alternate cooling and heating of the risers cracked the plaster at the ceilings, that the top floor, having a cold ceiling, developed cold-air pockets (which were not eliminated until around 10 a.m.) and that putting the 125-lb. h.r.t. hand-fired forced-draft boilers on a peak of 150 per cent rating from 6 a.m. to 9 a.m. developed tube and setting trouble.

A Question For Our Readers

AN oil-fired boiler not properly equipped with soot blowers has accumulated on the outside of the tubes a thick deposit of hard - baked, asphaltum-base scale or slag. What is the easiest and most economical means of removing this slag prior to the installation of soot blowers?

W. B.

Suitable answers (of 200 words or less) from readers will be paid for and published in the Nov. 19 issue.

In consequent practice we disregarded the shut-off valves on the fifth floor and kept an even 68 to 72 deg. F. temperature for the full 24 hr., giving entire satisfaction to the tenants and the boiler room staff, the moral effect of each shift having an equal share of work resulting in increased all-round efficiency.

The differential vacuum system was used in this case. The method finally adopted was to raise the vacuum on the return lines after 6 p.m., the heat losses through window opening not being as great after that hour.

Toronto, Ont. L. D. Ross.

DURING the last three years I have had charge of 21 public buildings. In 1926 this same question arose, so a close check was made of fuel and temperatures to determine costs and savings, if any.

We found that during a cold winter night it was not economy to allow building temperatures to drop more than 20 to 25 deg. below the normal temperature of 70 deg. From experience, I find that in severe cold weather no drop should be allowed. Further experiments during the last three years proved that with temperature-control apparatus in a building actual heating took place only 11 per cent of the total time the building was vacant. Further, by holding the temperatures not lower than 45 deg. created a saving in fuel of from 20 to 40 per cent.

Carrying these temperatures eliminates repairs due to freezing of the plumbing equipment, and damage to furniture from a sudden rise of temperature from a low point.

Glenn P. Milner.
Racine, Wis.

THE amount the temperature may fall at night involves many factors, such as location, outside temperature, type and tightness of construction, and ability to bring temperature back to normal.

But why allow temperature to drop at all? With a properly installed and maintained system it should be more economical to hold an even temperature throughout the 24 hr. when the weather is cold.

Personal experience leads to the belief that an overnight temperature decrease and the accompanying inrush of cold air on arrival of tenants leads to complaints. The loss of a single tenant through lack of proper heat will outweigh any possible gain.

Only with centralized control can the temperature be uniformly lowered throughout the building, and very few buildings are so equipped.

Ralph J. Dalton.
Cleveland, Ohio.

I WOULD SAY that if all the tenants are out of the building by 6 p.m. the steam can be shut off half an hour before closing time. Then if the building is occupied only by the cleaners and the night force the temperature can be allowed to drop to 64 deg. F. without any complaints from them. If a number of offices are occupied all night, it is our practice to run a separate line to these offices, if not too widely separated, rather than heat the entire building to 70 deg. all night. Even in zero weather we do not hold steam on the entire building all night.

The schedule followed in the Fox-Poli and Worthington buildings in Springfield, Mass., permits the temperature control as shown:

Outside Temperature Deg. F.	Steam On—From	Steam On—To
0	1 a.m.	7 p.m.
10	2:30 a.m.	6 p.m.
20	3:30 a.m.	5:30 p.m.
30	4:30 a.m.	5 p.m.
40	5:30 a.m.	4:30 p.m.
50	6:30 a.m.	10:30 a.m.

Extreme wind conditions will, of course, reduce the time that we can have the steam shut off at night. Then we leave the center section of the building shut off 1½ to 2 hr. longer than the end section, which has more exposed surface.

A. F. Sheehan.
Springfield, Mass.

DIESEL POWER for Water-Works

In this paper on the subject of economy and reliability of Diesel engines, the writer has purposely refrained from becoming enmeshed in the technicalities of engine design, but discusses the advantages of Diesel power for water-works. Operating costs are cited and economies compared.

By A. D. Couch*
Supervising Engineer
Community Water Service Co.
New York City

A PROBLEM that confronts every water-works man at times is the buying of new machinery to extend capacity or to replace machinery no longer economical. When this problem presents itself, as it often does, to the Community Water Service, a comparison is set up between the costs of operating with the existing plant and the calculated costs with other forms of power. About two years ago this comparison was formulated for one of our plants, which contained three horizontal tubular boilers and two horizontal duplex triple-expansion pumps. The equipment had an output of three million gallons per day, was in very good condition, and was housed in a beautiful building.

With the thought that the existing economy might be improved, the comparison was made of various drives as shown in Table I.

These are not merely hypothetical figures, worked out for this paper only, but the actual figures tabulated at the time this study was made, with the exception, of course, of the last column, which could not be arrived at until the Diesel plant had been installed. The first column was arrived at by averaging the costs of the last five years of steam operation. It will be noted that the total operating costs amounted to $29,000, in round figures.

The second column represents an estimate of the operating costs that would be expected if motor-driven centrifugal pumps were installed and power was purchased at 2c. per kilowatt-hour, the best rate obtainable. You will note that the yearly operating cost would be in the neighborhood of $28,760, as against $29,000 for the existing steam plant. Clearly, there would be no advantage in making a change to electrical power. Of course, it should be borne in mind that the cost of current may be materially cheaper in some localities than in this particular case, but to be cheaper than the final figure in the last column, electricity would have to be bought at approximately 1.1c. per kilowatt-hour.

The third column represents an estimate for the Diesel installation. This shows a total operating cost of $16,730, or an operating saving over the existing steam plant of well over $12,000 per year.

On a basis of 15 per cent fixed charges per year, a Diesel engine plant costing as high as $80,000 could be justified. The estimated price for a Diesel installation was $43,000. In comparisons of pumping plants, all figures are reduced to cost per million foot-pounds pumped. On this basis, the electric plant shows fixed charges plus operating costs of $0.01343; and the Diesel plant, $0.01048. No fixed charges for the steam plant have been shown, for reasons already given, but it is readily seen that even with the steam plant costing nothing to build, the Diesel plant would still be the best. It was therefore decided to install a 338-hp. Diesel arranged to drive a 3,000,000-g.p.d. centrifugal pump through a step-up gear. The complete installation also included a 25-kw. generator, connected to the pump shaft, to generate current for lights, low-lift pumps and to meet any other auxiliary plant requirements.

The last column of figures represents the actual costs of the Diesel installation, and covers the first year's operation. It will be noted that the total operating cost was $13,798, as against the estimated figure of $16,730, a further saving of almost $3,000. One reason why the total cost was so much lower than was estimated was that the send-out increased by more than 100,000,000 gal. over the assumed figure.

TABLE I—YEARLY COST OF WATER PUMPING

	Steam[1]	Electric[2]	Diesel[2]	Diesel[3]
Coal at $6.50	$12,869	$360	$360	$302
Power at 2c. per kw.-hr.		22,200		
Fuel oil at 6.7c. per gal.			7,350	7,034
Lubrication	800		420	496
Machine repairs	1,000		400	172
Pump repairs	Included above	200	150	
Labor	13,275	6,000	7,800	5,396
Supplies	1,000		250	498
Operating total	$28,944	$28,760	$16,730	$13,798
Initial investment		$7,100	$43,500	$43,000
Fixed charges, 15 per cent		1,065	6,525	6,450
Total yearly cost		$29,825	$23,255	$20,248
Million gal. pumped	800	800	800	923
Head, ft.	335	335	335	309
Million ft.-lb.	2,220,000	2,220,000	2,220,000	2,462,044
Operating cost per mil. ft.-lb.	$0.01304	$0.01295	$0.00754	$0.00560
Total cost per mil. ft.-lb.		$0.01343	$0.01048	$0.00822

[1]Average for five years. [2]Estimated. [3]Actual.

TABLE II—ECONOMIES OF DIFFERENT TYPES OF DRIVES

	Plant No. 1	Plant No. 2	Plant No. 3	Plant No. 4
Type of pump—low-lift	None	None	Cent.	Air lift
—high-lift	Geared centrifugal	Geared triplex	Cent.	Triplex
Number of engines	1	1	2	1
Horsepower, each	338	40	360	60
Gallons per day, low-lift			1,900,000	125,000
Total head, low-lift, ft.			35	100
Gallons per day, high-lift	2,880,000	700,000	1,860,000	125,000
Total head, high-lift, ft.	307	190	286	248
Million ft.-lb. per 100 lb. of fu l oil	324	264	205	148.6
Operating cost per million ft.-lb.	$0.00515		0.00723	$0.0242

To cover engine repairs an estimated figure of $400 was used, but the actual cost was $172. It is a well-known fact that repairs to a Diesel engine increase year by year up to the five-year mark, at which time considerable maintenance work will be necessary. The engine then should be rendered practically as good as new, and the cost cycle will return to that of the first year. Therefore, with this in mind the $400 figure shown in the estimate represents a fair average for a five-year cycle.

In concluding the description of this station, it may be stated that the duty of this plant as actually found in the guarantee test was 354,400,000 ft.-lb. per 100 lb. of fuel consumed, or slightly better than the guaranteed duty of 348,174,500 foot-pounds.

The relative advantage of various types of pump drives in Diesel water-works plants can be deduced from

*Abstract of paper read before the American Water Works Association, Portland, Me., Sept. 18.

Table II, covering some of the Community Water Service Company plants.

These figures were taken from our records for the month of May, 1929. They should serve as a fair example, since this month is neither the lightest nor the heaviest of the year.

Plant No. 1 is the same as has been previously covered in Table I. Plant No. 2 contains a 40-hp. engine direct connected to a triplex pump, while No. 3 has two 360-hp. engines direct connected to generators supplying current to the motors driving the pumps. Plant No. 4 has a 60-hp. power engine direct connected to an air compressor which furnishes air to operate the air-lift pumps, and belted to a triplex pump for high-lift pumping.

It will be noted that the gear-driven installations are the most efficient and that the air-lift installation is the least efficient.

To picture the comparative costs of steam plants, purchased-power plants and Diesel plants three good average plants operated by the Community Water Service Company have been selected. The costs, on the basis of million foot-pounds, are given in Table III, the Diesel plant being the one given in Table II as Plant No. 1.

TABLE III—AVERAGE OPERATING COST

	Steam	Purchased Power	Diesel
Million gal. per day	8.17	2.35	2.88
Average head, ft.	316	341	.....
Million ft.-lb. per month	669,887	207,485	.....
Efficiency, wire to water, per cent	.....	71.2	.....
Coal, tons per month	620	.....	.....
Operating cost, per mil. ft.-lb.	$0.00818	$0.0063	$0.00515

These records were also taken for May, 1929. The steam plant selected contains triple-expansion, corliss-valve pumping engines and is located where coal can be delivered in the bins for approximately $3.33 per short ton. The purchased-power plant buys current for approximately 1¼c. per kilowatt-hour.

It may be said, however, that these figures do not indicate that Diesel engines are always to be installed under all conditions. If Diesel engines would fit every case there would be no necessity to set up any figures in advance. It often appears that equipment of a certain kind is installed, which does not exactly fit the case, due to certain desires and prejudices of the purchaser, that excluded the Diesel engine when this type of equipment should have been used.

When the Community Water Service Company investigates any particular situation it does so with an entirely open mind and without any desire to install any particular kind of equipment.

Those who have operated Diesel equipment for a number of years do not doubt its reliability, but it is hard to overcome this doubt in others until they have actually had the experience. The writer knows this from his own case, for he well remembers the anxiety felt over the purchase of the first Diesel he was expected to operate. This engine was installed in 1914 and is still in operation.

In conclusion, it may be said that if duplicate Diesel engine equipment is installed in any plant no complete shutdown should occur if the machinery is given good care and attention. The reliability of Diesel engines under these conditions will equal that of any steam equipment and will exceed that obtained with purchased power, especially if the power comes in over long transmission lines, as is the tendency today.

Means for Increasing Reliability of Fusible Tin Boiler Plugs

FUSIBLE boiler plugs for safeguarding steam boilers against the dangers of low water have been in use for many years, and since 1852 they have been required in all steam vessels of the American merchant marine, except those equipped with pile, flash or coil boilers. They are also used in many factory and locomotive boilers.

In its usual form, the fusible plug consists of an externally threaded bronze casing filled from end to end with pure tin, which has a melting point of about 231 deg. C. The plug is screwed into the boiler in such a position that it is about one inch or more above the dangerous low water level, one end of the plug being on the water and the other on the fire side. If the water in the boiler falls below the level of the plug the tin melts and is blown out, thus releasing the steam pressure and serving to prevent burning and possible explosion of the boiler.

On May 11, 1914 a boiler of the steamship "Jefferson" exploded, causing the loss of life of several persons. It was shown that this explosion had resulted from low water and consequent overheating of the boiler plates. This should have been indicated by the melting of the filling of the fusible plug in that region, but the plug was found to be unmelted and apparently sound. The plug was forwarded to the Bureau of Standards for determination of the cause of failure. A thorough investigation showed that the filling contained only traces of the original tin, embedded in a matrix of tin oxide, which upon test showed a melting point of 1,600 deg. C. This oxide was distributed in such a form and quantity that it held the full steam pressure and would not have melted before the bronze of the plug casing or even the steel of the boiler plates. Actually such a plug constituted a serious hazard instead of a safeguard.

As a result of this investigation a thorough study was undertaken to determine the causes of the formation of this tin oxide. It was found that as little as 0.3 per cent of zinc or lead in the tin caused a dangerous deterioration, which was eliminated by insisting upon the use of a tin of high purity, containing not more than 0.3 per cent total impurities. Since this first work was undertaken fifteen years ago the bureau has tested boiler plugs regularly for the Steamboat Inspection Service. More recently another type of deterioration has been noted, the formation during service of a hard refractory substance replacing the tin filling in the fire end of the plug.

Special apparatus was devised to test plugs under simulated service conditions of steam pressure and temperature. Through the co-operation of the Steamboat Inspection Service 184 plugs were returned in the condition as removed from boilers of various types, including low- and high-pressure boilers, both coal and oil fired. It was found that about 10 per cent of all plugs would not function when subjected to steam of a temperature slightly above the melting point of tin. The failure of the plugs to function was due in every case to the presence of a refractory material in the fire and consisting principally of oxides of copper and tin, and in some instances of calcium and magnesium. It was shown that the formation of tin and copper oxides was the result of a partial melting of the tin filling and subsequent oxidation. The calcium and magnesium oxides were shown to have come from the boiler water through a leak in the plug resulting from incomplete bonding of the filling to the casing. As a result of the investigation changes in the existing specifications for fusible plugs were recommended to the Steamboat Inspection Service which it is believed will prevent the crust formation and thus further insure the proper functioning of this valuable safety device.

THE LEEDS & NORTHRUP COMPANY, of Philadelphia, Pa., has issued a bulletin, No. 871-A, that discusses temperature measurements in the rotating fields of generators. Since it is impossible to measure temperatures in the rotating field with the methods commonly used for taking stator temperatures, an apparatus making use of the Kelvin bridge has been developed by Leeds & Northrup. The quantity measured is the resistance of the field winding, metered in such a way that a continuous record of the temperature of the winding can be observed or recorded directly from the instrument. A complete description of the instruments and circuit, and a price list for the various types of apparatus available are also contained in the bulletin.

A TYPOGRAPHICAL ERROR was responsible for the words "Ontario" and "Quebec" appearing in direct contradiction to the text of an article on page 517 in the Oct. 1 issue of *Power*. Although the mistake was discovered and corrected, it is probable that some readers received copies of the magazine containing the erroneous tabulation.

Some Economic Considerations of Water-Wall Installations

By Ollison Craig*
Consulting Engineer
Riley Stoker Corporation

THE walls of boiler furnaces, on an increasing number of power plants, are being covered, in whole or in part, by water-cooled surfaces. These surfaces may be bare tubes or they may be tubes covered by metal blocks or by refractory material. In some cases metal is arranged to present a continuous surface by interposition of metal strips between bare tubes.

The purpose of installing such surface depends on individual conditions. If the furnace is fired by powdered coal it may be for protection of the walls, prevention of slag, increased capacity, or increased boiler efficiency. If the furnace is stoker-fired it may be for protection of the walls, prevention of slag formation on side walls or tubes, prevention of clinkers in the fuel bed, protection of metal parts of the stoker, increased capacity or increased efficiency.

In most boiler furnace installations a limiting factor is temperature, and this factor influences the others. In this case refractory walls are affected by high temperature in a number of ways. Softening of the wall material may occur. Undue expansion may be experienced, demanding special constructions. Certain combinations of ash and fireclay result in chemical reactions at high temperature, which causes deterioration of the brick. In any of these cases furnace-wall maintenance is affected.

Slag formation in the bottom of a furnace is expensive of removal, unless the ash is at all times kept so molten as to permit removal by tapping. Tapping, in general, is not practicable except in cases of special design, and even then is not desirable except with low-fusion ash.

Attempts to secure higher capacity or higher efficiency in either a powdered-coal-fired furnace or in a stoker-fired furnace usually result in higher furnace temperatures. Higher capacity demands a higher fuel-burning rate and a higher rate of heat release, resulting in higher temperature in a given furnace. Increase in efficiency may be obtained by less excess air being used or by returning to the furnace heat recovered from the flue gases. Either results in higher furnace temperature.

The Importance of Temperature

Furnace temperature, then, limits both capacity and efficiency. The effect of water tubes in furnace walls is to absorb heat by radiation, leaving less heat in the gases, and to produce a lower temperature in the furnace than would be the case with refractory walls entirely exposed, assuming all other conditions, particularly as to rate of fuel-burning ratio of coal to air, and furnace volume, the same in each case.

Since the action of slag is the cause of most of the furnace difficulties, and since the other difficulties become quite minimized if furnace temperatures are such that slag does not occur, it may be said that the temperature at which softening of ash occurs is the desired limit of furnace temperature, the combination of fuel-burning rate, rate of air supply and water-tube surface exposed should be such that this temperature should not be reached.

Water Walls do not Increase Efficiency

The presence of water tubes in a furnace reduces furnace temperature but does not directly effect over-all boiler efficiency to any considerable extent through reduction in temperature alone. Water tubes in furnace walls absorb heat radiated from the flame and furnace gases, which heat is transmitted to the water contained in the tubes. This heat finally appears in the steam leaving the boiler. The amount of heat that the flame and gases give up to the furnace walls is greater when water tubes are present than when the walls are entirely refractory. As a result, gases will then enter the first bank of boiler tubes at a lower temperature. This is on the assumption that other conditions are the same; that is, that the same weight of coal is burned per hour and that the coal is burned with the same amount of air, or that the CO_2 in the gases is the same. The gases enter the boiler tubes at a lower temperature as a result of this heat absorption in the furnace, but leave the boiler tubes at only a slightly lower temperature. Under these assumed conditions the only gain in thermal efficiency that can be realized is in lower exit-gas temperatures. If, then, the difference in exit-gas temperature is negligible, the gain in thermal efficiency is negligible.

With a given boiler and with a given operation, the addition of surface exposed to radiation equivalent to 6 per cent of the boiler-tube area will result in reduction of gas temperature from 2,500 deg. to 2,000 deg. F., but the final gas temperature will be reduced only about 13 deg. With 14 per cent CO_2 in the gases, this 13-deg. decrease represents about one-third of 1 per cent of the heat in the coal.

We may say, then, that water-cooling a furnace does not result in any appreciable increase in thermal efficiency if the same amount of coal is burned with the same amount of air. Thermal gain through the use of water tubes in the furnace is obtained through burning coal with a smaller quantity of air or with a higher percentage of CO_2 than would be permissible with refractory walls.

If burning a pound of coal results in the release of 14,000 B.t.u. and the production of 15 lb. of gas, and if 5,000 B.t.u. are radiated to surrounding surfaces, the absorption of the remaining 9,000 B.t.u. will result in a temperature rise of about 2,230 deg. F., or a total temperature of 2,300 deg., of the gases entering the boiler tubes if air is supplied at 70 deg. F. If the ash in the coal softens or fuses below this temperature, trouble will be encountered due to slag in the furnace. The above condition represents about 14 per cent CO_2. If slag results, it will then be desirable either to arrange for more heat to be absorbed by radiation or to operate at a lower percentage of CO_2. It will be seen then that the addition of water tubes in the furnace in such a case will result in high thermal efficiency through permitting higher CO_2 to be maintained. This is practically the only way in which water-cooled walls can result in higher boiler efficiency.

For example, assume a boiler with 5,000 sq.ft. of heating surface, burning coal the ash of which fuses at 2,300 deg. F. Assume the projected area of boiler tubes exposed to the furnace to be 200 sq.ft., and that it is desired to burn the coal with 14 per cent CO_2. If the boiler operated at 200-lb. pressure, the exit-gas temperature would be about 610 deg. F. and the thermal efficiency would be about 79 per cent, when developing 200 per cent of rating. Under these conditions the temperature in the furnace would be about 2,550 deg. F. and would result in slagged ash.

Water Walls not Always Justified

It would be necessary to reduce the CO_2 to about 12 per cent or to place water tubes in the furnace walls having an exposed projected area of about 150 sq.ft. Prices for such walls vary up to $35 per sq.ft. At $20, the cost of the water-cooling would be $3,000. If, instead of spending the money for water-cooling, the furnace were operated at 12 per cent CO_2, the resulting efficiency would be about 75 per cent. If the coal burned contained 14,000 B.t.u. per lb. and cost $5 per ton delivered, the difference in cost of coal for one year would be about $4,000, providing the boiler operated at this load for 24 hr. a day and 300 days a year. Obviously, in such a case it would be decided to install the water tubes in the furnace wall.

Assume, however, that high rating was a peak that occurred only occasionally and that the total time during which this load was carried amounted to only the equivalent of 30 days' continuous operation. If water-cooling were installed the cost would still be $3,000, while the saving in coal cost would be only $400. If off-peak loads did not exceed about 200 per cent rating, then water tubes would not be installed and the furnace would be operated with 12 per cent CO_2 during peak loads.

*Abstract of a paper presented at the Third National Meeting of the A.S.M.E. Fuels Division, Philadelphia, Pa., Oct. 7, 1929.

Relation of Power to Industrial Development Shown by International Survey

IN COMPARING the electrical development of the various nations, misleading results often arise through the neglect of several important factors, according to an article by Hugh Quigley appearing in a recent number of *World Power* (London). It has been considered sufficient in comparing electrical development to take output by public utilities; but such a method is fundamentally misleading, for public utilities alone may account in one country for less than 50 per cent of the national output of energy from all sources, and in another country for more than 90 per cent. On the other hand, when we attempt to secure a complete picture of the entire prime-mover capacity of many countries, requiring figures on private industrial plants, the lack of accurate reports has been a decided handicap.

Of course prime-mover capacity itself is not significant of the state of industrial development, the article points out. One country may have modern equipment and another country old equipment, the former deriving a much higher output at lower cost from the same power capacity.

Another factor that must be taken into account is the type of industry which has been established. A country with large natural resources will develop raw-materials industries that require a heavy plant capacity per ton of output. With industries of this type, such as coal-mining, iron and steel, etc., the power equipment must be heavy, while the value of production in monetary value may not be as high as in the finishing industries. Thus United States, Germany, Great Britain, France and Belgium can show a large prime-mover capacity located in these industries, and their preponderance has brought the national total up to a high figure. Other countries without these resources have concentrated on industries where labor and the quality of workmanship decide industrial value. Industrialization may be more intense in countries like Switzerland and the north of Italy, for example, than in metallurgical countries, though the figures on prime-movers indicate the opposite.

It is in the amount of electrification of industry that Mr. Quigley finds a significant factor. The economic significance of electrification lies in the possibilities it affords for mass production and long-distance transmission of power, so that natural resources can be tapped easily, developed economically and rendered available for national purposes. In other words, prime-mover capacity as reflected in the use of electrical equipment has become a sure indication of the state of modernization of industrial equipment, and electrification, therefore, gives a logical basis of assessment in connection with the prime-mover capacity of a country.

If one assumes that over 80 per cent of electrical power consumption, direct and indirect, goes into manufacturing operations of some kind, motive power capacity in industry should make it possible to draw a broad distinction between countries where a very high power production per head of population may be expected and other countries where a much lower level of development should take place.

The three statistical tables presented here are reproduced from Mr. Quigley's article. They show figures for those countries for which reliable statistics are available. It may be assumed, according to the article, that the figures given in Table I represent at least 80 per cent of the motive power capacity of the world. Two points of special interest are to be found in this table: the high degree of water-power development in the United States, Canada and Italy, and the preference shown by Germany for gas engines.

Japan and America Lead

In Table II an effort has been made to limit the issues purely to industry. No census figures were available for Italy, Switzerland and France, but it is assumed that a higher degree of electrification than even in Germany or America would be recorded, owing to the entire dependence of those countries on water-power plants. It is significant that figures for Japan and America, where industrial growth has been rapid, head the list, while Great Britain, which has been more conservative as to change and expansion, is next to last.

In Table III, prime-mover capacity and electric power production have been reckoned per head of population. (Note that the unit is not "per worker in industry," the more common American figure.) By these statistics, Canada rates as the most highly industrialized country, followed by Switzerland, United States, Great Britain, Germany, France and Italy. Modifications are made in these figures, however. The Canadian figures are abnormally high, owing to the preponderance of one great power-consuming industry—pulp and paper making—combined with the exportation of 1,600,000,000 kw.-hr. to the United States annually. If allowance is made for these factors, Canada ranks about the same as Great Britain. Allowance for the fact that in Switzerland great amounts of electrical energy are consumed in the electro-chemical and electro-metallurgical field, as well as for the fact that 960,000,000 kw.-hr. are exported, would probably reduce the Swiss figure to that of France, giving the United States the lead.

TABLE I—PRIME-MOVER CAPACITY (HP.)

Country	Year	Steam-Power Plant	Water-Power Plant	Internal Combustion, etc.	Total
United States	1927	45,376,000	10,520,000	1,659,000	57,555,000
Great Britain	1924	15,019,000	204,000	1,196,000	16,419,000
Germany	1925	17,757,000	2,038,000	2,020,000	21,815,000
France	1926	7,400,000	2,800,000	607,000	10,870,000
Italy	1927	3,374,000*	5,000,000		8,374,000
Canada	1925	993,000	4,013,000	77,000	5,083,000
Switzerland	1923	124,000	1,199,000	16,000	1,686,000†
Holland	1926	1,066,000	24,000		1,090,000
Poland	1925	1,568,000		88,000	1,656,000
Japan	1926	2,007,000	2,308,000	55,000	4,370,000
Total		94,684,000	28,106,000	5,718,000	128,918,000

* Including internal combustion engines, etc.
† Including power purchased.

TABLE II—ELECTRIC MOTORS INSTALLED IN INDUSTRY (HP.)

Country	Year	Total of All Electric Motors	Total of All Primary Power + Motors Driven by Purchased Energy	Degree of Electrification (Per Cent)
United States	1927	29,084,000	39,239,000	75
Great Britain	1924	7,942,000	15,494,000	51
Germany	1925	11,625,000	17,657,000	66
Canada	1925	1,983,000	2,946,000	67
Holland	1926	315,000	571,000	55
Poland	1925	267,000	994,000	27
Japan	1926	2,293,000	2,593,000	88
Total		53,509,000	79,494,000	67

TABLE III—INDUSTRIAL AND ELECTRICAL DEVELOPMENT

Country	Population (Millions)	Prime-Mover Capacity per Head of Population hp.*	Index U.S.A. = 100	Electrical Power Production per Head of Population kw.-hr.	Index U.S.A. = 100
United States	115.0	0.500	100	844	100.0
Great Britain	44.0	0.374	75	356	42.2
Germany	62.5	0.350	70	402	47.6
France	40.0	0.272	54	325	38.5
Italy	38.7	0.216	43	236	27.9
Canada	9.4	0.540	108	1600	185.0
Switzerland	3.9	0.434	87	1175	139.0
Holland	7.4	0.147	29	179	21.2
Japan	59.7	0.073	15	180	21.3
Poland	27.2	0.061	12	77	9.1
Total	407.8	0.317	63	475	56.3

* Note: This is not the "horsepower per worker in industry."

Events and Men in Power's Field

THE EDITORS WILL WELCOME THE CO-OPERATION OF READERS IN REPORTING INTERESTING HAPPENINGS, PERSONAL OR OTHERWISE

Spot * News

EQUIPMENT *consisting of six 33,500-hp. hydraulic turbines has been ordered for the $30,000,000 Osage River development by the Union Electric Light & Power Company, of St. Louis, from Allis-Chalmers Manufacturing Company.*

* * *

SEPTEMBER SALES *of mechanical stokers, as reported to the Department of Commerce by the ten leading manufacturers in the industry, totaled 152, of 44,485 hp., as compared with 199, of 54,929 hp., in August and 161, of 65,060 hp., in September, 1928.*

* * *

A NEW RECORD *for a single day's output of its system was recently established by the New England Power Association when it produced 6,094,908 kw.-hr. in 24 hr. The association also broke its hourly peak record with a total of 367,200 kw.-hr. for a single hour.*

* * *

THE LARGEST CITY *in the new world decided to buy from the largest single operating power company the largest block of power ever contracted for when New York City recently awarded the contract for furnishing electrical energy to operate its new subway system over a period of ten years to the New York Edison Company.*

* * *

ALL THE PLANTS *of the Duke Power Company, of Charlotte, N. C., are again operating at full capacity, after being interrupted for a few days by the recent high water in the two Carolinas, it has been announced by officials of the power corporation.*

* * *

GROSS EARNINGS *of public utility enterprises, exclusive of telephone and telegraph companies, for the first eight months of 1929 amounted to $651,500,000, as compared with $554,432,512 for the same period in 1928, according to the Department of Commerce.*

Light's Golden Jubilee Reaches Climax at Dearborn Ceremony

Edison Re-enacts Construction of First Electric Light in Old Menlo Park Laboratory—President Hoover and Many Notables Take Part in All-Day Celebration

WORLD attention was focused, Oct. 21, on the little town of Dearborn, Mich., where the greatest tribute ever paid a living genius reached its climax. There, in company with President Hoover, Henry Ford, the faithful band of Edison Pioneers and a group of 500 American notables, Thomas Alva Edison reconstructed his lamp of 50 years ago and made the electrical connection that caused it to light. Five months of national and international celebration of Light's Golden Jubilee culminated in this fitting ceremony, marked for its simplicity.

An all-day celebration led up to the principal event. Distinguished guests arrived at Detroit in the morning, where they were met and entertained by Henry Ford. In the afternoon members of the party boarded a quaint train for Dearborn—an exact replica of the old Grand Trunk train on which Edison at the age of 12 worked as a newsboy between Port Huron and Detroit. On arrival at Dearborn the guests found themselves in the center of Ford's early American village, where Edison was presented to President Hoover.

Dedication of Ford's museum and the American village took place in the afternoon. Among the famous buildings in this village are the depot in which Edison learned telegraphy, the Postville Court House, in which Abraham Lincoln first won renown as a lawyer; an exact replica of Independence Hall; and Edison's original Menlo Park laboratories, where the incandescent electric light was first brought to practical commercial use. At the village town hall, Henry Ford gave an address of welcome, to which William S. Barstow, president of the Edison Pioneers, responded.

Dinner was served in Independence Hall, after which the guests gathered at Edison's historic laboratories for the significant event of the ceremonies. These laboratories have been transferred piece by piece from their original home in Menlo Park, N. J., and re-erected, with from 75 to 85 per cent of the original material, at Dearborn. Even Edison's footprints across the wet cement floor have been preserved, to add a personal touch to the inventor's early workshop. In this familiar setting Edison, with the aid of his old assistant, Francis Jehl, now 70, reconstructed the first electric light bulb. He then turned on the steam of the old engine, starting the original generator, and closed the switch that gave the first electric lamp commercial life.

Following this ceremony, President

Insignia of Light's Golden Jubilee

The medallion, designed by Franklin Booth, was adopted as the official insignia for Light's Golden Jubilee to commemorate the fiftieth anniversary of the perfection of the incandescent lamp by Thomas Alva Edison.

Hoover paid tribute to Mr. Edison in an address which eulogized the inventor's contribution to civilization. Mr. Edison acknowledged the honor paid him in a few simple words. Other speeches followed which further emphasized the importance of Edison's work.

A national and international radio hook-up embracing the three great network systems broadcast the events of this celebration. Thousands of lighted airplanes flew over the principal cities of the country during the evening. The lighting of Ford's airport was the final event on the program. Ablaze with the illumination of millions of candlepower, the airport provided the crowning spectacle of the ceremony.

All over the country similar observances of the occasion took place. New York's most famous thoroughfare, Fifth Avenue, was bathed in amber glow, and many city officials took part in the celebration. An extensive program of lighting was sponsored throughout the cities of New Jersey. St. Louis, Mo., was dedecked in multi-colored lights, shot through with the piercing rays of powerful air beacons. Night flying of illuminated planes was a feature of Chicago's display. A widespread civic observance of the jubilee took place in cities on the Pacific Coast and throughout the far West.

In every civilized country of the world some part was taken in this greatest of all celebrations—Light's Golden Jubilee.

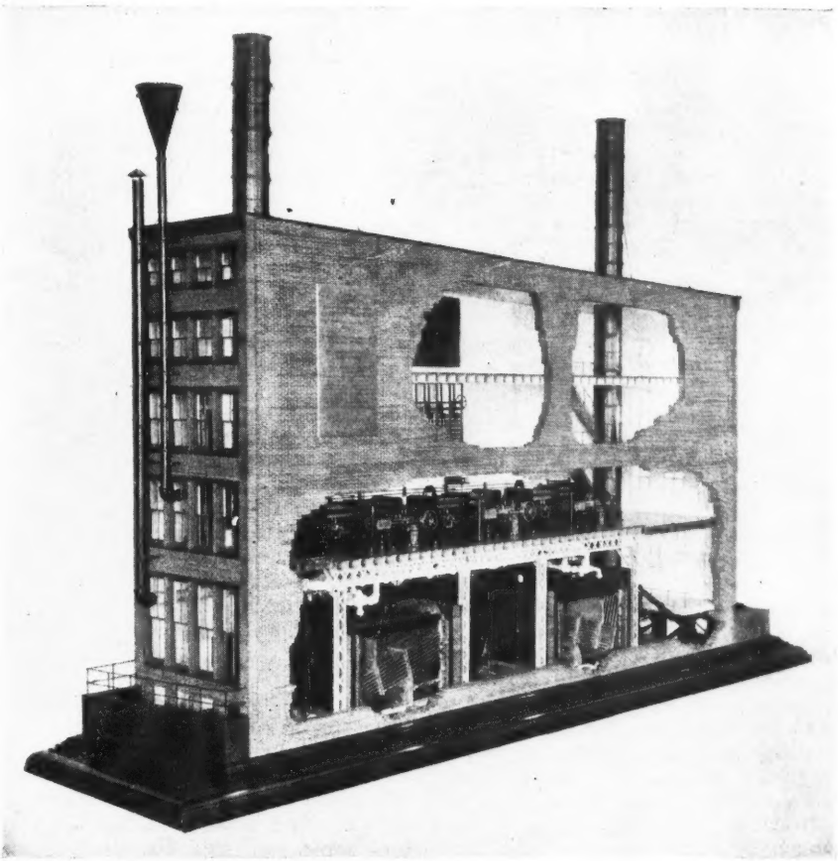
Einstein Pays Tribute to Edison

Albert Einstein, the famous exponent of relativity, in a letter from Germany to Edward L. Bernays, pays the following tribute (translated) to Thomas A. Edison on the occasion of Light's Golden Jubilee, directly addressing the inventor in the second paragraph:

"The future writer of history will ascribe a high significance to our time because of the far-reaching changes of the conditions of life of humans which have carried them along on the path of a tremendous technical development. The human and animal muscle was relieved by the machine; the surface of the planet was melted down into economic entity through the completion of means of travel and transportation as well as of communication. Through this our time has created the prerequisites for a political union of mankind, which development, however, can only progress slowly owing to the backwardness of human traditions and valuations.

"Among the heroes of this world-historical process, you, honored Herr Edison, occupy a prominent rôle through having contributed a large share to make electric power serviceable to mankind. As one whose life has been made precious by his work, accept gladly this expression of thanks and heartfelt admiration."

Model of Old Pearl Street Station Now in Ford's Museum



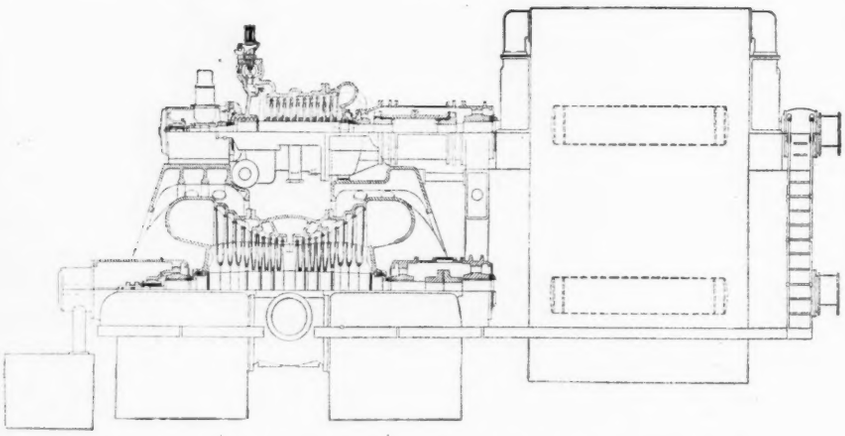
AT THE inauguration of Light's Golden Jubilee at Atlantic City, N. J., in May, Henry Ford became so interested in the working model of the old Pearl Street generating station that Matthew S. Sloan, president of the New York Edison Company, offered to give him one. Ford accepted the gift with delight, and placed the model in his museum at Dearborn, Mich., along with other historic power plant equipment.

Interesting anecdotes are told about peak loads on the old station, one of the most amusing being that related by William T. Dempsey, of the Edison company, of the 780-kw. load which occurred one day in December, 1890. The scene in the Pearl Street boiler room at this time was one of tense nervousness. The fireman in charge of the four 200-hp. Babcock & Wilcox water-tube boilers strained every effort to keep up the steam pressure, which was generated quickly by roaring wood fires on top of the coal. In the engine room the crew was alert and somewhat nervous under the great strain of keeping the apparatus in operation to meet the heaviest load which up to that time had ever been carried on the system from 8th St. to the Battery, and from river to river. The many oil cups on the numerous moving parts of the high-speed horizontal engines were watched over carefully, hands being inserted among the flying, moving parts to feel the temperature of the bearing points. The dynamo tenders had attached cans filled with ice to the bearings of the dynamos, being careful to see that only oil and not water worked through to the bearings on the armature shaft. Each and every man in the engine room and fire room knew that all the generating apparatus was being operated under tremendous strain, and it was a matter of great pride and relief when the peak load period was carried safely over the top. The load was 6,500 amp. or 780 kw., the equivalent of 15,600 50-watt lamps, which was the maximum demand on the system south of 8th St. on Manhattan Island in December, 1890.

The accompanying picture shows a working model of the old Edison power plant. The plate on the outside wall bears the following inscription:

"Model showing the interior of the historic Edison Central Station, 257 Pearl St., New York City. Scale—one-half inch equals one foot. Commenced operation Sept. 4, 1882, destroyed by fire Jan. 2, 1890. Original equipment consisted of 125 normal hp. 350-r.p.m. Porter-Allen engines, each directly connected to an Edison Jumbo dynamo having a capacity of 1,200 16-candlepower, 110-volt lamps. Steam at 120 lb. pressure was supplied by four Babcock & Wilcox boilers. Original engines were replaced by Armington and Sim engines shown in the model."

Largest Vertical Compound Turbine to Be Installed by Ford



Sectional sketch of 110,000-kw. double-deck turbine-generator

THE most modern turbine-generator so far conceived, rated 110,000 kw., is to be installed by the Ford Motor Company in the power-generating station of its River Rouge plant, at Fordson, Mich. This machine, involving many novel and unusual features of design will represent the last word in up-to-date generating equipment. Its tremendous electric output, far exceeding the rating of any existing prime mover used for industrial purposes, will be used in the manufacture of Ford automobiles.

The new machine represents interesting departures in design and construction. It is a vertical compound unit and is the first machine of such large capacity to be made to this design. As shown in the sketch, the high-pressure turbine and generator will be mounted directly on top of the low-pressure turbine and generator, resulting in the most compact unit yet proposed. Each element has a capacity of 55,000 kilowatts.

One of the important features of the design—of particular value in the Ford plant, where floor space is at a premium—is the small amount of space that will be taken up by the new unit. The general dimensions include a length of 57 ft. 6 in., a maximum width of 23 ft. and a little less than 21 ft. over-all height from the floor. The approximate weight is 2,000,000 lb. The space to be occupied is less than a quarter of a cubic foot per kilowatt of output.

Two older generating units, rated 12,500 kw. each, are to be moved out to make room for the new machine. Striking evidence of the improved design of the new machine is that in spite of its tremendously greater output it will occupy approximately the same floor space in the power plant as did the two older units, and produce, instead of 25,000 kw., 110,000 kw. Considerably more than twice as many kilowatts will be generated for a square foot of floor area than in any other recent large power installation.

Of General Electric make the new machine will use approximately 50 per cent less coal to produce a given number of kilowatt-hours than the units to be removed, and it will require less than a pound of coal to generate a kilowatt-hour of electricity.

Steam will enter the upper turbine unit at 1,200 lb. pressure and, after producing 55,000 kw., will flow into reheaters. In these reheaters steam at 1,200 lb. pressure direct from the boilers will reheat the steam exhausted from the high-pressure turbine, which will then flow down and into the low-pressure unit, where it will produce another 55,000 kilowatts.

Air coolers will be built integral with the generators and will be connected so that the heat losses in the generators will be recovered and returned in the feed water. The combination of all these elements—the large 1,200 lb. turbine, the steam reheat, the economies of compact design—will result in one of the most efficient steam stations in the world.

To supply cooling water for the new unit a tunnel will be constructed connecting the River Rouge with the Detroit River. This tunnel will be 3½ miles long, 15 feet in diameter and will deliver 600,000,000 gallons of water every 24 hours.

Large Hydro Power Plant for Susquehanna

Application for a license to construct a hydro-electric power plant, with a total capacity of 231,000 hp., at Safe Harbor, Pa., on the Susquehanna River, has been filed with the Federal Power Commission by the Safe Harbor Water Power Corporation, of Holtwood, Pa., a subsidiary of the Pennsylvania Water & Power Company.

Involving an expenditure of more than $30,000,000, the initial installation at Safe Harbor will consist of six generating units with a total capacity of 231,000 hp. Provision will be made in the power house foundation, however, for an ultimate installed capacity of over 500,000 hp. According to present plans, the dam will be 3,635 ft. long and will raise the pond to an initial elevation of 225 ft. above sea level, affording a head of 52.5 feet.

Construction will begin early next spring. It is expected the construction contract will be awarded to the Arundel Corporation, of Baltimore, Md. When completed, the new plant will be tied in with the 150,000-hp. hydro plant eight miles downstream at Holtwood, which supplies power to Baltimore. These two developments will ultimately provide a total capacity in excess of 650,000 hp., making the system one of the most important water power operations in the world.

American Diesel Engines Made in Belgium

That American engineers are capable of producing Diesel engines which are the equal of any in the world is evidenced by the fact that Carels Freres, of Ghent, Belgium, recently have completed its first engine under license from the Worthington Pump & Machinery Corporation. The engine, a 4-cylinder, 2-cycle double-acting unit developing 4,000 b.hp. at 128 r.p.m., has cylinder 28 in. in diameter and a stroke of 40 in. It is similar to the engines furnished the United States Shipping Board and is to drive a large alternator in South America. A second engine of this design is now being built by Carels Freres for service in the same power station.

Carels Freres is among the pioneer builders of Diesel engines. It also has a license from the Ingersoll-Rand Company to manufacture the Price solid-injection oil engine

Large Power Plant to Open at Hams Hall, England

Wednesday, Nov. 6, is the day officially set apart for the opening of the new power station of the Birmingham Corporation Electric Supply Department at Hams Hall, near Coleshill, England. The new generating station, which upon its completion will be among the largest in the country, forms an integral part of the electricity commissioners' scheme for the Midland area. The site of the new station was acquired in 1919, but it was seven years after that the city council authorized the electric supply committee to proceed with the erection of the first section of the power station, comprising a 60,000-kw. plant, at an estimated cost of $6,682,000. When the full scheme is completed the station will have a capacity of 210,000 kw., and the total cost will, it is estimated, have amounted to close on $10,500,000.

The contract for building and equipping the station with 60,000 kw. of plant (with provision for a further 30,000 kw.) was entered into with In-

ternational Combustion, Ltd., in July, 1927, and it was a condition of the contract that the first generating set should be completed and ready for service within twenty months. Sufficient progress has been made to justify the expectation that the first set will be ready to take next winter's load.

The problem of altering the frequency from 25 cycles to the standard 50 cycles adopted for the country as a whole is being overcome by stages. As part of the program, two 18,750-kw. machines known as "frequency changers" will be installed at the Nehells (Prince's) station, which will enable the corporation to supply 50-cycle current from its own 25-cycle machines as a temporary measure. When opportunity serves, one of the large generating sets at Hams Hall will also be rewound and made suitable for 50-cycle supply. The other will be altered later. Initial steps have been taken for the establishment of the main transmission lines contemplated under the scheme, as well as for the selection of suitable sites for transforming stations for dealing with supplies for the "grid."

New Steam Plant for Baton Rouge Refinery

Negotiations have been completed by the Engineers Public Service Company for supplying substantially the entire steam and electric power requirements of the large Baton Rouge refinery of the Standard Oil Company of Louisiana, a subsidiary of the Standard Oil Company of New Jersey. To meet the terms of the contract, the Louisiana Steam Products, Inc., of Baton Rouge, a newly formed subsidiary of the Engineers company, will build at once a boiler plant capable of supplying the estimated refining plant demand of over 6,000,000,000 lb. of steam a year, and an electric generating plant of 45,000 kw. capacity, to cost approximately $6,000,000. The gross business covered by the contract with the Standard Oil Company is estimated to be $1,600,000 annually.

Hydro Development Planned for Skykomish River

Application has been filed in Olympia, Wash., with the state hydraulics supervisor by the Puget Sound Power & Light Company, Seattle, for permission to appropriate 1,060 sec.ft. of water from the south fork of the Skykomish River in eastern Snohomish County, Wash., for a power development project.

The plant, which would have an output of 20,500 hp. and would be built at an estimated cost of $1,825,500, would be located about a mile east of the town of Index and near the confluence of the north and south forks of the river. A concrete diversion dam 15 ft. high and 300 ft. long would be built, and a fall of 170 ft. would be utilized in the project.

John Anderson Dies in Milwaukee

John Anderson, vice-president in charge of power of the Milwaukee Electric Railway & Light Company, Milwaukee, Wis., died suddenly in his home Oct. 14. He was 57 years of age.

Born at Aberdeen, Scotland, into a typical Highland clan, Mr. Anderson started his career at the age of thirteen as an apprentice to a machinist and engine builder. Supplementing his work with a technical course in one of

John Anderson

the few night schools in Liverpool, England, he graduated from the shop at the age of nineteen as a thorough journeyman machinist and engineer. He immediately came to America and took a position as an oiler with the International Mercantile Marine Company. From 1890 to 1907 he filled every mechanical post in the company up to chief engineer.

In 1907, he deserted the sea to enter the employ of the Union Electric Light & Power Company of St. Louis as engineer in charge of steam heating. After seven years in this position, he was promoted to chief engineer of the power plant department of the Milwaukee Electric Railway & Light Company, where he had charge of design, construction and operation of all the company's power plants and heating systems in Wisconsin. Subsequently he was appointed vice-president of the company in charge of power.

During the World War, Mr. Anderson's long and successful marine experience was brought to the attention of Secretary of the Navy Daniels, and he was made consulting engineer for the transport branch of the United States Navy, covering the operation of more than 500 vessels. He was a member of the American Society of Mechanical Engineers and the Engineering Society of Milwaukee.

As chief engineer of the Milwaukee company Mr. Anderson became interested in the possibility of burning pulverized fuel under central station boilers, and designed many large installations.

News of Canada

Power Agreement Ratified With Calgary—Work Started on Chats Falls Project—St. Maurice Development Progressing—Fall River Dam Construction to Start Soon

AN IMPORTANT power agreement has just been ratified between the city of Edmonton, Alberta, and the Calgary Power Company. The city secures hydro-electric power from the company's developments on the Bow River, west of Calgary, and in turn will sell power from the municipal steam-electric plant to the Cargary Power Company at certain periods of the year when the water in the Bow River is low. The Edmonton station will be in the position of a powerful stand-by plant. An important feature of the new power contract is that it enables the city to defer large capital expenditures in extending its steam-electric station. The Edmonton steam plant is in a better position than any other plant in the province to supply steam-generated electric power at a minimum cost.

Another outstanding feature of the agreement is that Alberta will have the highest voltage electrical transmission line in western Canada. The contract involves the construction of a 132,000-volt line which will connect Edmonton and intermediate towns with the company's plants on the Bow River. The largest transformers in western Canada will be used and substation equipment is being ordered and will be installed during the winter months. The whole line should be completed and in operation early in 1930.

Chats Falls Project Started

Work has commenced on a big hydro-electric project at Chats Falls, on the Ottawa River, where it is planned to develop about 250,000 h.p. The land is being cleared on the Quebec side of the river preparatory to the construction of a huge cofferdam, 30 ft. in height. The power rights on this side of the river are controlled by the Royal Securities Corporation, and Nesbitt, Thomson & Company, of Montreal, two large financial houses. The contract for the dam has been awarded to Morrow & Beatty, of Peterboro, Ontario. The contract involves the erection of a dam running from the Quebec shore into the Ottawa River a distance of about three-quarters of a mile. Expenditure on this portion of the dam will be approximately $2,500,000. It is expected that the power development on the Ontario side will be undertaken by the Ontario Hydro Electric Power Commission, and that the entire scheme will involve an expenditure of $7,500,000.

Progress on St. Maurice

Marked progress is being made by the Shawinigan Water and Power Company, of Shawinigan Falls, Quebec, in the groundwork preparatory to car-

rying out its big hydro-electric scheme on the Upper St. Maurice River. A large crew of surveyors and other men is now in the field, and it is expected that the preliminary work will be finished this fall. Construction will start on or before July of next year. Last year the company entered into an agreement with the provincial government under which the company secured a 75-year lease for all the power formed by the rapids in the St. Maurice River above La Tuque. There are four sites in this stretch of water. As these powers are situated a relatively short distance below the Gouin dam, both efficiency and economy will be promoted in the use of the company's present storage facilities.

The agreement provides that the company must have 100,000 hp. developed three years after July 1, 1930, and that the company shall carry out succeeding developments so that the fourth will be started by July 1, 1938. In the company's last annual report it was pointed out that with the development of these water powers and proposed additional storage works. Shawinigan will have power resources on the St. Maurice River of 1,279,000 hp. All of this electrical energy is within 150 miles of Montreal.

FALL RIVER DEVELOPMENT

Work on the Fall River power development of the Northern British Columbia Power Company, near Prince Rupert, will begin shortly. The power house will be built about 500 ft. above the fork of the falls of the Ecstall River and will be connected with a dam 750 ft. distant by steel penstocks. The initial head will be 200 ft. Four units with a total capacity of 30,000 hp. will be installed. The Northern British Columbia Power Company is a newly formed subsidiary of the Power Corporation of Canada.

Tacoma to Acquire More Hydro Sites

Negotiations for the acquisition by the city of Tacoma of additional power projects with a claimed total available capacity of 80,000 hp. continuous generation, were revealed recently by Ira S. Davisson, commissioner of the city utilities department, in the introduction of an ordinance to appropriate $40,000 for engineering studies. Options on the property have been approved.

Water rights, dam sites, reservoir sites and other rights and properties needed for power generation on the Duckabush, upper and lower Dosewallips and the Hamma Hamma Rivers are included in the option taken by the city from Elbert M. Chandler, of Olympia, and the Hamma Hamma Power & Paper Company. The consideration asked is $370,000. The properties lie in Mason and Jefferson Counties, and the power lines to Tacoma would connect up with the Cushman transmission line, with a maximum of 30 miles additional transmission. The largest power development would be on the Hamma Hamma River, on which an appropriation of 350 sec.ft. of water has been made. On the lower Dosewallips River 150 sec.ft. of water have been appropriated.

The studies of the power project will be made under the direction of J. L. Stannard, chief engineer of the public utilities department.

Coming Conventions

American Institute of Electrical Engineers. District meeting at Chicago, Ill., Dec. 2-4. Annual winter convention at New York, N. Y., Jan. 27-31, 1930. F. L. Hutchinson, secretary, 33 West 39th St., New York City.

American Society of Mechanical Engineers. Annual meeting at New York, N. Y., Dec. 2-6. Secretary, Calvin Rice, 33 West 39th St., New York City.

American Society of Heating & Ventilation Engineers. Annual meeting in Philadelphia, Pa., Jan. 27-30, 1930, at the Benjamin Franklin Hotel. Secretary, A. V. Hutchinson, 33 W. 39th St., New York City.

National Association of Practical Refrigerating Engineers. Twentieth annual convention at the William Penn Hotel, Pittsburgh, Pa., Nov. 4-7. Secretary, E. H. Fox, 5707 W. Lake St., Chicago, Ill.

National Exposition of Power and Mechanical Engineering. Grand Central Palace, New York City, Dec. 2-7. Charles F. Roth, manager, Grand Central Palace, New York City.

World Engineering Conference, Tokyo, Japan, October, 1929. All correspondence should be addressed to the Secretary, World Engineering Conference, Nikon, Kogyo Club, Morunouchi, Tokyo.

OBITUARY

ERNEST F. HARDER, assistant to the vice-president of the Westinghouse Electric & Manufacturing Company, died Oct. 13 of pneumonia at his home in East Orange, N. J. Mr. Harder was born in Rostock, Germany, and came to this country at the age of 25 to enter the employ of the Westinghouse company at Pittsburgh as a foreman. The late George Westinghouse was just beginning his work with the alternating current, and Mr. Harder was one of the Westinghouse plant's first employees. He was with the company for 41 years. Characterizing him as a brilliant pioneer of the electrical industry, H. P. Davis, vice-president of the Westinghouse company, said that most of the original line of meters and switches was developed under Mr. Harder's supervision.

HORACE WILLOUGHBY, 58, president of the Crane Company, died recently following an illness of 2 years. He was also secretary of the National Pipe and Supply Company.

PERSONALS

FRED. J. POSTEL, on Oct. 1, resigned his position as assistant general manager of the Pabst Corporation, Milwaukee, Wis. It is the intention of Mr. and Mrs. Postel to go South for the winter and return in the spring ready for active duty. Previous to his connection with the Pabst Corporation, it will be recalled that Mr. Postel was a consulting mechanical engineer specializing in power plant work, with offices in Chicago.

WILLIAM WOODWARD has been elected director of the Babcock & Wilcox Company of New York City, succeeding J. G. Eustis, deceased. C. W. Middleton has been appointed secretary of the company.

L. J. BELNAP, president of the Worthington Pump & Machinery Corporation, New York City, recently served on an advisory committee to the National Industrial Conference Board in its survey of educational conditions. Among other members of the committee were E. M. Herr, of the Westinghouse company, and William E. Wickenden, president of the Case School of Applied Science.

H. E. BRELSFORD, formerly chief engineer of the technical department of the United States Shipping Board and more recently works manager of the Buffalo factory of the Worthington Pump & Machinery Corporation, is now connected with the Diamond Power Specialty Corporation, of Detroit, Mich., where he has taken charge of the research department.

RALPH PALMER, chief engineer at the Alexandria plant of the Virginia Public Service Company for the past seven years, has resigned on account of poor health. William Wood has been appointed chief engineer to succeed him. Mr. Wood was formerly Mr. Palmer's assistant.

A. W. BERRESFORD, president of the American Engineering Council and for many years prominently identified with the electrical industry, has been named managing director of the National Electrical Manufacturers' Association to succeed Alfred E. Waller, resigned.

ERNEST ZSCHAU, distribution engineer of the Nebraska Power Company, Omaha, has been named industrial engineer of the Chamber of Commerce there. Mr. Zschau entered the employ of the company in 1924 and was assigned to the power station as a switchboard operator. He remained for approximately a year, and during this period he also engaged in some electrical work for the Phoenix Utility Company. Subsequently he was transferred to the engineering department.

Business Notes

Yarnall-Waring Company, Philadelphia, Pa., announces the appointment of Roger A. Martin as its Southeastern representative, to succeed Samuel D. Barr who recently resigned. Mr. Martin, who is a graduate in mechanical engineering of the Georgia School of Technology, will make his headquarters at the company's Atlanta office.

Palmer-Bee Company, Detroit, Mich., announces the appointment of George M. Demorest as its district representative for Pittsburgh and vicinity. Mr. Demorest has engaged in sales promotion work on speed reducers, power transmission and conveyor equipment for more than twelve years.

Homestead Valve Manufacturing Company, Coraopolis, Pa., announces the appointment of C. E. Ruth as its district sales manager for the territory including northern Pennsylvania, Ohio, western New York and Ontario. Mr. Ruth was formerly with the engineering department of the Rust Engineering Company.

Allis-Chalmers Manufacturing Company, Milwaukee, Wis., recently appointed A. J. Schmitz as its representative in the Portland, Ore., territory. Mr. Schmitz came to Portland from Havana, Cuba, where he represented the company for eight years.

General Electric Company, Schenectady, N. Y., reports that its orders for the three months ending Sept. 30 amounted to $116,688,014, compared with $90,328,666 for the corresponding quarter of 1928, an increase of 29 per cent. For the nine months ending Sept. 30 orders received totaled $337,404,470, compared with $260,686,463 for the first nine months of last year, also an increase of 29 per cent.

Trade Catalogs

Combustion Control — The Gray system of automatic combustion control is fully described in a 28-page booklet recently issued by the Automatic Fuel Saving Company of Philadelphia, Pa. Well illustrated, the bulletin gives three layouts of typical installations of the Gray system.

Generators—Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., have recently issued three illustrated leaflets on modern generating units. Leaflet 20355-A describes type ES engine-driven a.c. generators; leaflet DMF-5182 is entitled, "Modern Auxiliary Power and Lighting Equipment"; and leaflet 3746-B gives the features of type MG synchronous motor-generator sets.

Stokers — "Illinois Chain Grate Stokers" is the title of an attractive new sixteen-page catalog just issued by the Illinois Stoker Company, Alton, Ill. Features of the forced-draft and natural-draft chain grates are given and numerous installation photographs presented.

Strainers—Bulletin A-4, one of the latest publications of the Elliott Company, Jeannette, Pa., brings complete information on strainers up to date. The various types of twin strainers, motor-operated strainers, oil strainers, intake strainers, etc. are described. Dimensions are included.

Flow Meters—"Why You Should Use Flow Meters" is the title of a valuable booklet recently published by the Brown Instrument Company, Philadelphia, Pa. It is a complete treatment of the effect of steam costs on business profits and the relation of flow meters to the problem of reducing steam costs. Many illustrations make the story more interesting to the non-technical reader.

Packings—An extensive treatise on the applications of Vim leather packings for water, air and oil has recently been published by E. F. Houghton & Company, P. O. Box 6913, North Philadelphia, Pa. The 136-page book contains much well-illustrated practical data on packing installations. Tables of sizes and price lists are also included.

General Engineering—An attractively illustrated booklet has been released showing the broad field Canadian Vickers, Ltd., Montreal, P. Q., Canada, serves. Illustrations of boiler installations, pressure stills, etc. are included.

With the Society Sections

A. S. M. E., Cleveland Section. Meeting Nov. 4, Cleveland Engineering Society rooms at 8 p.m., with the student branch at the Case School of Applied Science. Dr. W. E. Wickenden, president of the Case School, will give a general talk.

A. S. M. E., Metropolitan Section. Power meeting, Nov. 8, sponsored by the power division of the A. S. M. E.; chairman, Dr. Harvey N. Davis, president of Stevens Institute of Technology. Subject: "Recent developments in European Power Plants," by Joseph H. Keenan, professor of mechanical engineering, Stevens Institute.

A. S. M. E., Ontario Section. Inspection trip to the boiler plant of the Toronto Terminal Railways heating plant on Oct. 22. A trip will also be made to the power plant of the Royal York Hotel. Dinner will be served in the hotel at 7 p.m., followed by many interesting features. Mr. Meadows of the Royal York Hotel will talk on the equipment in the hotel.

A. S. M. E., San Francisco Section. Meeting, Nov. 7, Engineers' Club of San Francisco, at 7:30 p.m. Subject: "Licensing of Engineers," by L. F. Levrey, W. Stalder, C. H. Snyder and J. D. Galloway. These speakers are to give their ideas pro and con.

A. S. M. E., Worcester Section. Meeting, Nov. 7, C. T. Sherer Company's restaurant, at 6:30 p.m. Subject: "The General History of Mechanical Refrigeration," by F. L. Fairbanks, chief engineer of Quincy Market, Boston, Mass.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines: mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard	New York	$2.10 @ $2.45
Kanawha	Columbus	1.30 @ 1.60
Smokeless	Cincinnati	2.25 @ 2.50
Smokeless	Chicago	2.10 @ 2.25
S. E. Kentucky	Chicago	1.30 @ 1.60
Steam	Pittsburgh	1.40 @ 1.75
Gas Slack	Pittsburgh	1.00 @ 1.10
Big Seam	Birmingham	1.50 @ 1.75
Anthracite (Gross Tons)		
Buckwheat	New York	$2.65@ 2.75
Barley	New York	1.40@ 1.50

FUEL OIL

New York—Oct. 17, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4.75c. per gal.; f.o.b. Bayway, 36@40 deg., furnace, tank-car lots, 6c. per gal.

St. Louis—Oct. 11, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.5959 per bbl. or 42 gal.; 26@28 deg., $1.6459 per bbl.; 28@30 deg., $1.6959 per bbl.; 30@32 deg., $1.7459 per bbl.; 32@36 deg., gas oil, 4.901c. per gal.; 37@40 deg., distillate, 5.98c.

Pittsburgh—Oct. 8, f. o. b. local refinery, 30@34 deg., fuel oil, 4c. per gal.; 36@40 deg., 4.25c. per gal.

Philadelphia—Oct. 12, 13@19 deg., $1.05@$1.10 per bbl. or 42 gal.; 22 deg. plus, $1.575@$1.625 per bbl.; 23@27 deg., $2.10@$2.15 per bbl.

Cincinnati—Oct. 8, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5.25c. per gal.; 30@32 deg., 5.5c. per gal.

Chicago—Oct. 9, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 80@85c. per bbl.; 26@30 deg., 95c.@$1.00 per bbl.; 30@32 deg., $1.20 per bbl.

Boston—Oct. 14, tank-car lots, f.o.b., 12@14 deg., Baume 4.5c. per gal.; 28@32 deg., 5.6c. per gal.

Dallas—Oct. 12, f.o.b. local refinery, 26@30 deg., $1.30 per bbl. or 42 gallons.

New Plant Construction

COMPILED BY THE McGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Ark., Russellville—City voted bonds for the construction of 50 x 80 ft. power plant building, $139,350; distributing system, $82,571, and installing two 600 hp. Diesel engines and one 36 hp. engine, $21,500. W. L. Winters, 311 Merchants Natl. Bank Bldg., Fort Smith, is engineer.

Calif., Banning—Southern Sierras Power Co., 777 West 8th St., Riverside, is having plans prepared for the construction of a sub-station including power line from Banning to Palm Springs. Estimated cost $100,000. Private plans.

Calif., Berkeley—Regents of University of California, awarded contract for the construction of central heating plant to C. C. Moore Co., Sheldon Bldg., San Francisco. Estimated cost $186,581.

Calif., Crescent City—U. S. Government, Public Works Officer, 12th Naval Dist., 100 Harrison St., San Francisco, will receive bids until Nov. 6 for the construction of an 18 x 25 ft. power house here.

Calif., Downey—Downey Water District, plans an election to vote $195,000 bonds for the construction of a waterworks system including wells, pump station, etc.

Conn., Waterbury—Connecticut Light & Power Co., 107-111 West Main St., plans the construction of a substation on Baldwin St. Estimated cost $40,000. Private plans.

Fla., St. Petersburg—City, E. H. Lewis, director of Public Works, awarded contract for the constructing 15 m.g. p.d. high lift pumping station, 5 m.g. reservoir to Layne Southern Co., 742 29th Ave.

Ind., Evansville—Bd. of Water Works, will receive bids until Oct. 24 for waterworks improvements including pump room, etc. Estimated cost $18,000. Black & Veatch, 700 Mutual Bldg., Kansas City, Mo., are engineers.

Ind., Knightstown—Orphans Home, plans the construction of power house, including equipment at Indiana Soldiers & Sailors Orphans Home. Estimated cost $200,000. McGuire & Shook, 941 North Meridian St., Indianapolis, are architects.

La., Slidell—City plans surveys and estimates for construction of municipal light and power plant. Estimated cost $100,000. Swanson-McGraw, Inc., Balter Bldg., New Orleans are engineers.

Mass., Boston—Boston & Albany R.R. Co., G. A. Kirley, chief engineer, South Station, plans the construction of power house, including two 450 hp. boilers, Beacon and Hyde Parks. Estimated cost $225,000. Densmore, LeClear & Robbins, Park Sq., Bldg., Boston are engineers and architects.

Mass., Dorchester (Boston P. O.) — Owner, c/o A. W. K. Billings, Jr., 80 Boylston St., Boston, is having plans prepared for the construction of a 75 x 125 and 250 x 335 ft. ice plant at 200 Geneva Ave. Estimated cost $100,000. M. Linenthal, 333 Washington St., Boston, is engineer.

Mass., Somerville (br. Boston)—Boston Ice Co., 11 Deerfield St., awarded contract for the construction of a 1 story, ice plant to Vappi & Ferguson, 515 Massachusetts Ave., Cambridge. Estimated cost $40,000.

Mass., Somerville—Rubel Ice Corp., 937 Fulton St., Brooklyn, N. Y., taking new bids for the construction of 85 x 95 ft. ice plant, at Beachery Court. Estimated cost $100,000. A. W. K. Billings, Jr. Inc., Little Bldg., Boston is engineer. Former contract rescinded.

Mass., Turners Falls — Turners Falls Power & Electric Co., 3 Ave. A., awarded contract for the construction of Cobble Mountain power plant, to D. O'Connell's Sons Inc., 480 Hampden St., Holyoke.

Mich., Detroit—D. C. Grobbel, acting Secy., Department of Water Supply, 735 Randolph St., will receive bids October 30, for booster plant, at Springwells Station. Estimated cost $15,000. G. H. Fenkell, 735 Randolph St., is city engineer.

Mich., Detroit—Wayne Co., c/o Bd. County Road Commissioners, Barlum Tower, awarded contract for the construction of 1 story power house, Goddard and Middle Belt Rds., to M. H. Sobel, 510 Book Tower. $67,725.

Neb., Beatrice—State Dpt. P. Wks., J. A. Burford, Supt. State House, Lincoln, will receive bids after January 1st, for a 3 story, 80 x 160 ft. hospital and power house addition. Estimated cost $150,000.

Nev., Fallon—City is having estimates made for the construction of a municipal power plant. Cost exceeds $100,000.

N. J., Newark—R. Bolton, archt., 15 Branford Pl., is receiving bids for a 1 story, boiler house on McClellan St., for United Color & Pigment Co., Inc., Evergreen Ave. Estimated cost $40,000.

N. Y., Norway—Utica Gas & Electric Co., 222 Genesee St., Utica plans the construction of an electric light plant, and 10 mi. transmission line. Herkimer co.

O., Cincinnati—State of Ohio, Columbus, plans the construction of a 1 story, power house, Paddock Rd. Estimated cost $240,000.

O., Cleveland—Shattuck & Layer, Archts., North La Salle St., Chicago, Ill. taking bids for the construction of 27 x 120 ft. service station, 100 x 115 ft. boiler house, and 27 x 256 ft. repair shop, for Sinclair Automobile Service, Corp. of America, H. L. Nelson, 2540 West 22nd St., Chicago, Ill. Estimated cost $200,000.

Pa, East Stroudsburg—Dept. of Property & Supplies, F. St. Clair, Ch. Engr., Harrisburg, will soon award contract for the construction of a 1 story, 42 x 48 ft. power plant for State Teachers College, here. Private plans.

Pa., Oil City—Independent Refining Co., M. Tarbox, genl. mgr., awarded contract for the construction of boiler house, to L. O. Bouquin, 13 East 1st St. Estimated cost $110,000.

Pa., Philadelphia—High Court Apartments, c/o C. S. Caskary, 1701 Walnut St., Archt., awarded contract for a 4 story apartment building at High and Boynton Sts. to Aldine Construction Co., Wesley Bldg. Estimated cost $1,000,000.

Tex., Paris—City voted $60,000 bonds for the construction of a municipal ice plant. M. Fooshee, is engineer.

Tex., Port Arthur—Consumers Ice & Coal Co., c/o J. F. Jakowitz, pres. plans the construction of ice plant. Estimated cost $40,000.

Va., Richmond—American Tobacco Co., 26th and Carey Sts., plans the construction additions to power plant $81,000. C. H. Gibson, is manager.

Nova Scotia—Dominion Coal Co., constituent company of British Empire Steel Corp., Ltd., awarded contract for the design and construction of steam power plant, with a 7,500 k.v.a. steam turbine equipped with boilers and auxiliary apparatus to be built on tidewater at Glace Bay. Boilers to operate at 450 lb. steam pressure and to utilize pulverized coal, awarded to United Engineers & Constructors, Ltd., Montreal, Que.

Que., Montreal—City plans construction of power plant, 22,000 hp. capacity, at La Salle on St. Lawrence River.

Equipment Wanted

Boilers, etc.—Mayor and City Council, S. S. Cox, City Mgr., will receive bids until Nov. 1 for two 150 hp. horizontal return tubular boilers, two 150 kw. generators with unaflow or turbine engine drive, two 1,600 g.p.m. low lift pumps, one 1,000 g.p.m. high service pump, one 1,000 g.p.m. fire pump, etc., for proposed waterworks.

Ice Making Equipment—Arena Ltd., G. W. Hezzlewood, Pres., Oshawa, Ont., prices on ice making equipment for hockey arena.

Pumping Equipment—Allegheny County Commissioners, 519 Smithfield St., Pittsburgh, Pa., will receive bids until Oct. 29 for pump for swimming pool at South Park.

Pumping Equipment, etc.—City of Liberty, Tex., J. H. Hill, Secy., will soon receive bids for pumping equipment for sewage disposal plant.

Pump—City of Edna, Tex., pumping equipment for proposed sewage disposal plant.

Reactor Starting Equipment, etc. — Bd. of Water Comrs., D. C. Grobbel, Acting Secy., Detroit, Mich., will receive bids until Nov. 6 for furnishing and installing reactor starting equipment for synchronous pump motors and starting equipment for variable speed slip ring motors, together with switching equipment and motor generator sets for 20,000 kw. generator plant. Estimated cost $150,000.

Stokers—Bureau of Yards & Docks, Navy Dept., Washington, D. C., will soon receive bids for mechanical stokers at Naval Hospital, Boston, Mass.

Industrial Projects

Calif., Berkeley—University of California, is having sketches made for the construction of an engineering building including electrical and mechanical departments on Campus. Estimated cost $600,000. G. W. Kelham, 315 Montgomery St., San Francisco, is architect.

Calif., Burbank — Northrup Aircraft Corp., awarded contract for the construction of a 60 x 180 ft. factory at 50 x 60 ft., office at United Airport to Austin Co. of California, 777 East Washinton St., Los Aneles.

Calif., Fruitvale—Oliver United Filters Co. Inc., 4th and Madison Sts., Oakland, is having plans prepared for the construction of a group of buildings here. Estimated cost $500,000. Reed & Corlett, Oakland Bank of Savings Bldg., Oakland, are architects.

Del., Wilmington—Hercules Powder Co., Delaware Trust Co., plans the construction of experimental and chemical laboratories, including power house, on Lancaster Pike.

Ga., Savannah—Southern Building Products Co., and Certainteed Products Co., 100 East 42nd St., New York awarded contract for the construction of plant to Artley Co., 504 Bay St., Savannah.

Ind., Indianapolis—American Metal Furniture Co., 325 West 17th St., awarded contract for the construction of 150 x 200 ft., metal furniture factory, to Mothershead & Fitton, 960 North Pennsylvania St. Estimated cost $100,000.

Mich., Detroit—American Twist Drill & Tool Co., 2804 West Jefferson Ave., plans the construction factory. Estimated cost $100,000. C. W. Ditchy, 415 Brainard St., is architect.

Mich., Detroit—Silent Automatic Corp., 255 Meldrum Ave., awarded contract for the construction 7 story, basement, 100 x 120 ft., Jefferson Ave. to O. Misch Co., 159 East Columbia St. Estimated cost $700,000.

Mo., St. Louis—Dubinsky Realty Co., 504 Wainwright Bldg., is receiving bids for the construction of a 1 story, 75 x 130 ft. spring factory at 3133 Washington Ave. B. Shapiro, 1219 Syndicate Trust Bldg., is architect. St. Louis Spring Co., 3135 Washington St., is lessee.

N. J., Newark—Newark Rivet Works, 262 Lafayette Ave., awarded contract for the construction of a 4 story, 100 x 100 ft. factory to W. L. Blackard, 972 Broad St. Estimated cost $50,000.

N. J., North Bergen—General Box Top Co., c/o Bonanno Bros., 1827 Bergen Turnpike, Contrs., will build a 2 story factory at 39th St. Estimated cost $68,000.

N. J., Passaic—Lockwood, Greene Engineers, Inc., Engrs. and Archts., 100 East 42nd St., New York, receiving preliminary bids from selected list for the construction of 5 story, factory, 2nd and Canal Sts. for United States Rubber Co., 211 Passaic St. Estimated cost $1,000,000.

O., Cleveland—Columbia Metal Stamping & Die Co., A. E. Koch, Secy. and Treas., 1536 East 49th St., awarded contract for the construction of a 1 story, 90 x 220 ft. factory on East 116th St. and Harvard Ave. to H. K. Ferguson Co., Hanna Bldg. Estimated cost $150,000.

O., Cleveland—The Dill Mfg. Co., G. D. Williamson, Pres., 694 East 82nd St., manufactures of metal stampings, plans the construction of a factory on Mandaley Rd. Estimated cost $100,000. Robert-Wright Co., Swetland Bldg., is architect.

O., Cleveland—Osborn Mfg. Co., E. W. Hopp, supt., 5401 Hamilton Ave., awarded contract for the construction of 4 story factory, Hamilton Ave. to Hunkin-Conkey Constr. Co., Newman-Stern Bldg. Estimated cost $100,000.

O., Cleveland—E. T. Pierce Co., E. T. Pierce, Pres., 4903 Harlem Ave., die manufacturers, had plans prepared for a 1 story, 60 x 100 ft. factory on East 49th St. Estimated cost $50,000. G. A. Ebeling, 737 Prospect Ave., is architect.

O., Dayton—Delco Products Co., East First St., awarded contract for the construction of a 7 story, 67 x 135 ft. factory at Second and Madison Sts. to C. H. Shook, Third National Bank Bldg. Estimated cost $200,000.

Que., Hull—E. B. Eddy Co., Ltd., Hull, plans the construction of paper mill, Laurier Ave. $1,500,000. M. Pratt, c/o owner is architect.